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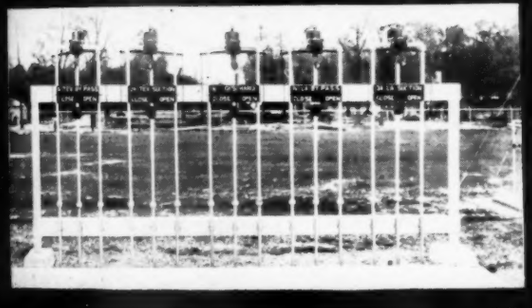

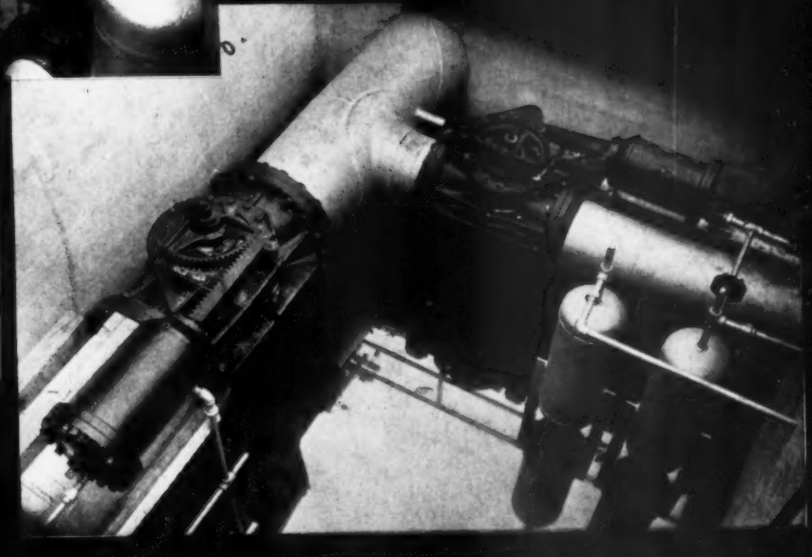

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Meetings

- Interstate Oil Compact Commission—July 12 and 13, Santa Fe, New Mexico.
- California Natural Gasoline Association—August 5, Richfield Building, Los Angeles, California.
- American Chemical Society—September 6, 7, 8, 9, and 10, Rochester, New York.
- Pacific Oil Show and Black Gold Festival—September 16, 17, 18, and 19, Taft, California.
- American Gas Association, 19th Annual Meeting—September 27, 28, 29, 30, and October 1, Cleveland, Ohio.
- Society of Automotive Engineers, Fuels and Lubricants Regional Meeting—September 30 and October 1, Tulsa, Oklahoma.
- Oil-World Exposition, Inc.—October 11, 12, 13, 14, 15, and 16, Houston, Texas.
- Independent Petroleum Association of America, Annual Meeting—October 14, 15, and 16, Houston, Texas.
- American Association of Petroleum Geologists, Mid-Year Meeting—October 14, 15, and 16, William Penn Hotel, Pittsburgh, Pennsylvania.
- American Welding Society, 18th Annual Meeting and Welding Exposition—October 18, 19, 20, 21, and 22, Atlantic City, New Jersey.
- Mid-Continent Oil and Gas Association of Texas, Annual Convention—October 29 and 30, Dallas, Texas.
- American Petroleum Institute, 18th Annual Meeting—November 9, 10, 11, and 12, Stevens Hotel, Chicago, Illinois.
- International Petroleum Exposition—May 14, 15, 16, 17, 18, 19, 20, and 21, 1938, Tulsa, Oklahoma.

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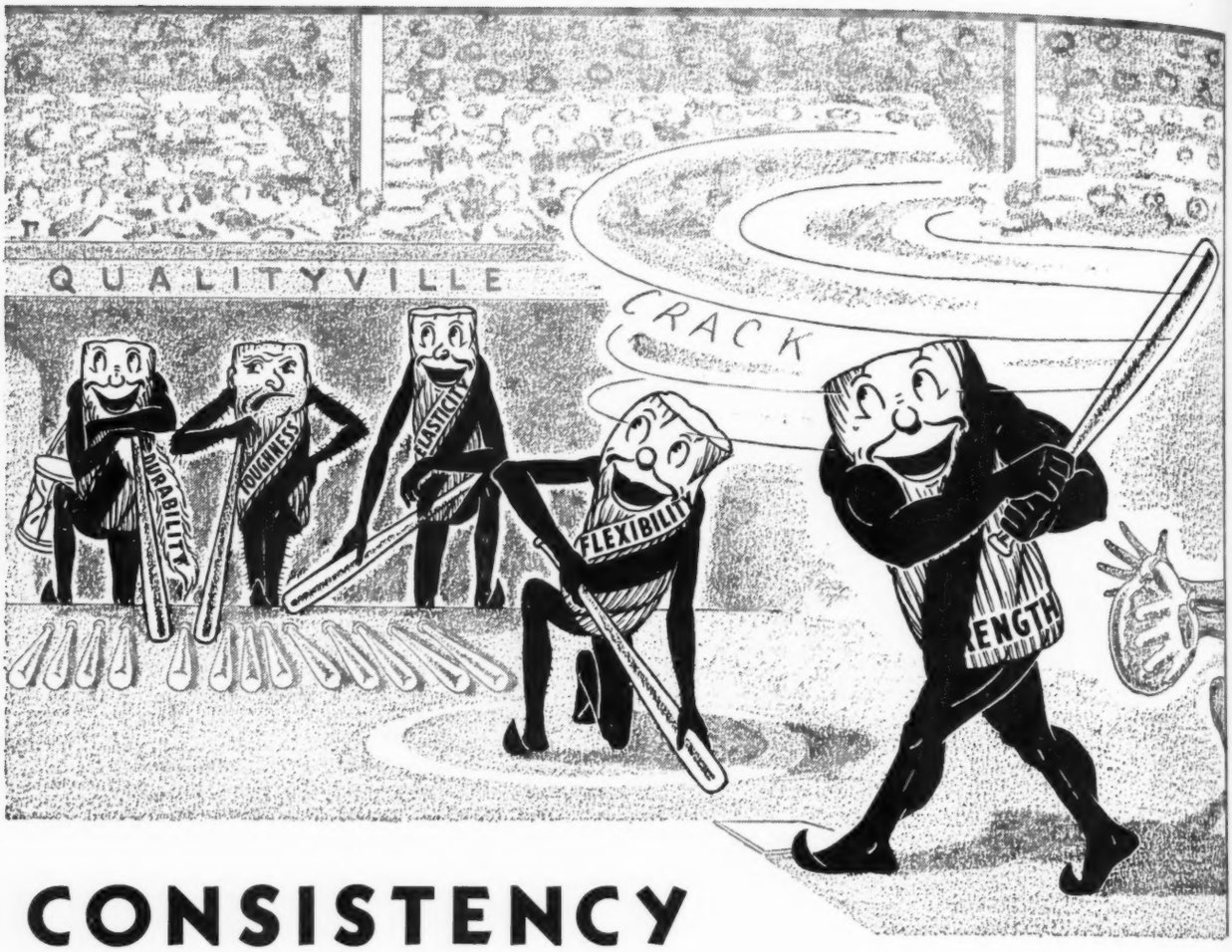

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Editorial

WITH overproduction and low crude prices now almost a matter of the past, its effects rapidly being forced into the background and forgotten under the stress of present activity, the petroleum industry during the last year has taken great forward strides—and the momentum seems only to be gathering headway.

Nationwide proration definitely has proven a success, the principal producing states being more closely joined in their interests by the activities of the Interstate Compact Commission. The production situation in the East Texas field probably is as near a satisfactory solution as it ever will be; only recently the Connally law was extended for a period of two years. Crude oil prices have shown substantial advances despite an increase in total production, the latter now being more than a billion barrels yearly for the first time in history. This situation, of course, has been made possible by the very large increase in the volume of gasoline consumed. The number of automobiles on the roads today is substantially greater than a year ago. The demand for gas-oil, distillate fuels, and residual fuel oils also has shown a marked gain.

The discovery of new oil pools has been a matter of frequent occurrence, traceable to the greater number of drilling activities. This in turn is accounted for by higher crude prices and the improved condition of the industry generally.

Wells continue to be drilled to greater and still greater depths. During the past year the honor of completing the world's deepest producing well changed hands several times. The one now having that distinction is Humble Oil and Refining Company's No. 1 Ellender in Terrebonne Parish, Louisiana, drilled to a total depth of 12,165 feet. Obviously, the drilling of wells to such great depths demands the most exacting engineering skill, as well as the most highly-improved equipment.

Nor has drilling activity been confined to areas within the United States. Perhaps never before has there been such a world-wide search for oil, the governments of some countries offering attractive concessions, and in certain instances even subsidizing such exploration efforts. The full import of these developments is not yet fully realized; they mark the beginning of a new era in world petroleum exploitation.

This intensive exploration has been attendant with rapidly-changing prospecting methods. Geophysics has served a most significant part in the search for geologic structures favorable to the accumulation of petroleum. Other branches of science also have played important roles; thus we find that this phase of petroleum development, which at one time was left more or less to chance, now has reached a high state of scientific accuracy. The operator of today knows before he spuds in a test that his chances of finding oil are at least within the realms of reason.

The economics of oil production steadily has encroached upon the consciousness of operators and one outgrowth has been the increasing effort to eliminate the drilling of wells unnecessary to economic oil recovery. Consequently, the trend is toward planned well-spacing, advocates of this method of curbing unnecessary drilling decrying the practice of prorating production on a potential basis without regard to the acreage drained, thus placing a premium on new drilling.

With such widespread activity in the petroleum industry during the year it was inevitable that substantial advancements should be made in operating technique as well as important additions and improvements to equipment. No phase of the industry has been without its developments. Water-flooding operations have come into more widespread use, repressuring and pressure maintenance advanced in their application, invaluable improvements have been made to methods of drilling-in under pressure, directional drilling definitely has proved its place and gone forward, important facts have been learned with regard to solving the problem of heaving shale, new uses are being found for bottom-hole chokes, and pumping methods definitely have improved, to mention a few of the drilling and production activities in which important progress has been made.

Equally important advances have been made in other branches of the industry—refining, natural gasoline manufacture, and pipe-line transportation. The modern automotive engine necessitates the manufacture of high-octane gasoline and high-quality lubricating oil. This demand in turn makes imperative constant improvements in processing and equipment. In the pipeline branch of the industry, construction, reconditioning, corrosion, welding, station design, etc., are phases of this important transportation work that yearly are becoming more highly technical and more standardized.

As a record of this great activity in the petroleum industry the publishers of *The Petroleum Engineer* offer this, the Annual Engineering Review Number, in an effort to bring to the reader a better perspective of the progress and trends in the various branches of the petroleum industry with particular reference to operating methods and equipment.

Digging a slush pit on a well site in Western Kansas. This work is expeditiously done by modern excavating machinery. The tractor shown at work here is powered by a Diesel engine and is removing soil at the rate of 300 cu. yards in eight hours

● A Review and Trends Practice

DRILLING activity in proven, semi-proven, and wildcat areas has proceeded at a brisk pace during the past year. On top of this, there has been much agitation for more rational drilling programs in proven fields—a question, of course, that is tied up with the well-spacing problem. The problem of well-spacing is a complex one and may involve many unknowns, so that frequently it is difficult to advance positive evidence that will aid in reaching agreement on what is the best spacing program for a field. Sentiment nevertheless is growing in favor of developing fields on a well-spacing program according to what is considered good engineering practice. The interest in this problem now evinced by almost all operators makes the outlook promising for further progress.

Drilling methods during the past year have come in for more consideration than usually accorded them. A trend toward portable drilling equipment for increasingly deeper drilling is evident.

Many refinements have been made on the unitizing of deep drilling equipment because of the economies possible.

Higher mechanical efficiency in drilling operations is being sought by engineers.

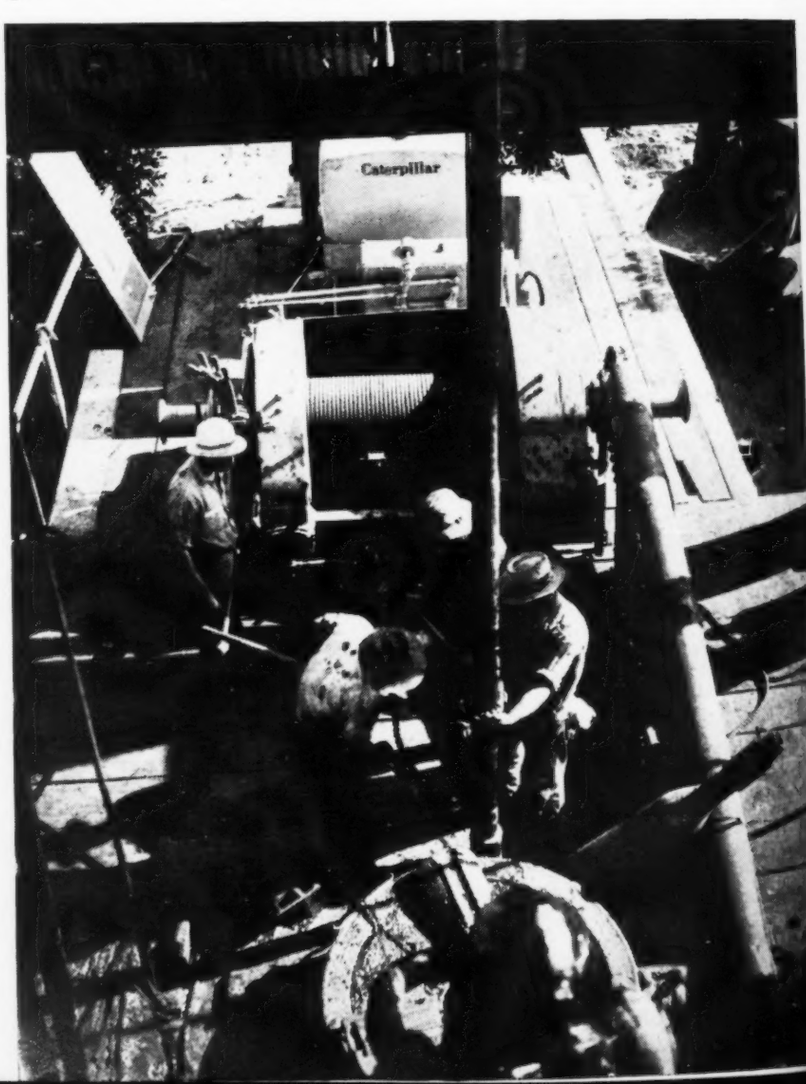
Casing and cementing operations, and also methods of well completion, likewise are under constant observation and improvements being added as needed.

Rotary Power Requirements

Field test data now are being sought on the energy consumed in drilling operations in its various phases. Tests have been made on electric-powered rigs in California to determine the power requirements for the rotary-table drive while drilling with various weights on the bit.[1] This study is important as indicating the possibilities of the individual drive for the rotary table.

Interesting observations have been made during these field tests. One is that power requirements increase rapidly as the weight on the bit is increased in soft formations. Tests made with a conventional 14¾-in. drag bit showed that at a table speed of 184 r.p.m. the maximum hp. required was 168; this was with three points weight on the bit (2700 lb. for each point), approximately a total weight of 8100 pounds. With only two points or 5400 lb. weight on the bit and a table speed of 184 r.p.m. the hp. output of the motor was 125.

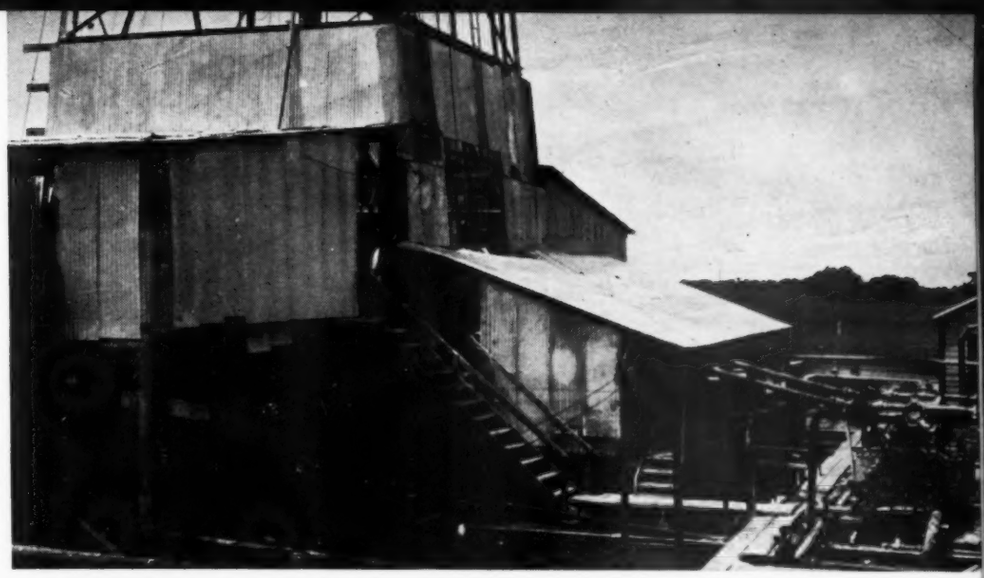
Another interesting point observed was that the load on the motor with zero weight on the bit was practically identical regardless of the amount of drill pipe used, being the same for 1350 ft. as for 3030 feet. A saving in hp. was observed to result from the use of the direct drive. In the case of



A well being drilled with portable rotary equipment mounted on a truck. Note safety guard on rotary chain

# of Progress in Drilling

By
K. C. SCLATER



A deep drilling well on the Gulf Coast that has encountered heaving shale. Elaborate precautions are taken to keep the mud constantly in proper condition. Note the housing over the vibrating mud screens. To the right are the mud pumps and on the extreme right can be seen the mud laboratory

a well 3062 ft. deep and using an 11-in. drag bit the approximate saving was approximately eight horsepower.

Higher drilling speeds may be looked for along with the adoption of the individual rotary-table drive. Table speeds of 500 r.p.m. are seen as a possibility in the not far distant future.[1] With a table speed of from 120 to 140 r.p.m. and using 6⅝ and 9⅝-in. core barrels the core recovery was practically 100 percent. These data are vital and more of it is bound to lead to greater improvements in drilling machinery and drilling practices.

Selecting Casing Size

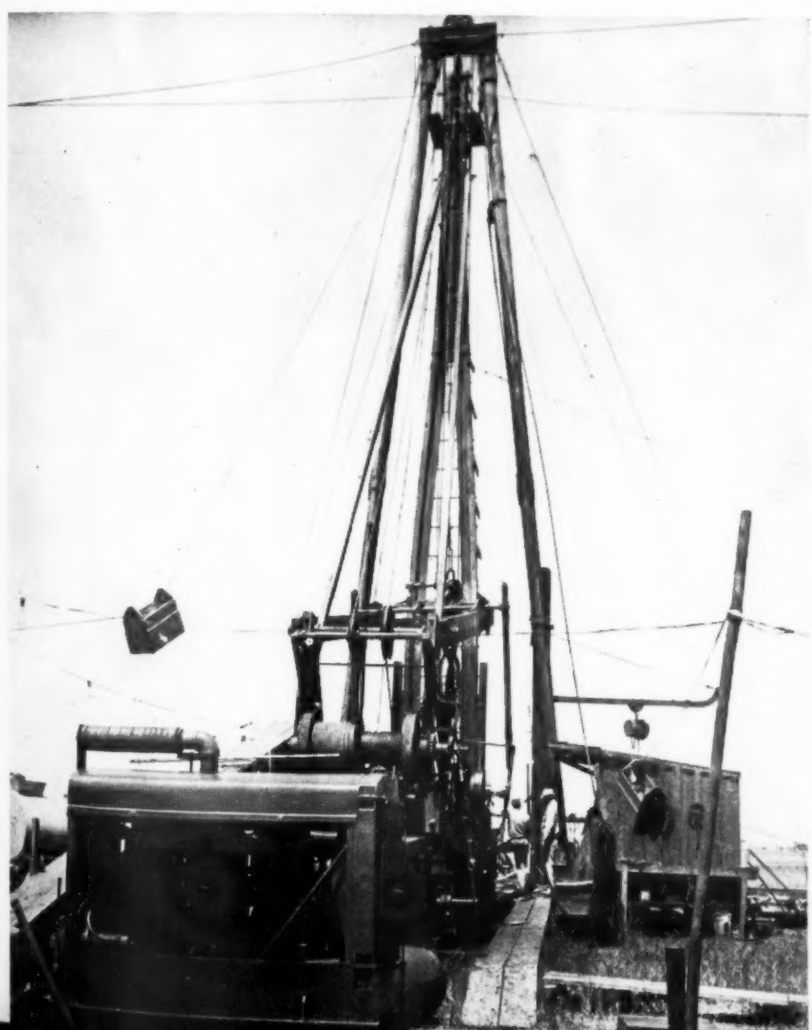
Selecting casing of the proper size for wells in California has been given some study.[2] In this connection it is stated that: "the best engineering, under present practice, is to drill the maximum size hole justified by the circumstances and then protect that hole by suitable casing, properly perforated." Of the total footage of selected sizes of surface and water strings of casing used in California during 1936 approximately 45 percent or 1,714,000 ft. was 8⅝-in. casing. Of the total footage of perforated pipe used in California during 1936 approximately 48 percent or 100,000 ft. was 6⅝-in. casing.

Attention is drawn to the fact that in selecting casing consideration should be given to the probable methods and equipment that will be used in producing the well throughout its life. "Unless there is room to install the various appliances of special gas-lift the operator is faced with inefficiency, high cost, and early abandonment." In the pumping stage the size of oil string is still important, even more so than at any other time. For this reason it is suggested that: "The pumping situation should be carefully analyzed and considered before the estimated saving by use of smaller oil strings is accepted as justifiable. The analysis may be made by checking a completed well for productivity index, and pump efficiency. It should be remembered that sucker rods are not the sole medium for well pumping. Attempt to anticipate the probable water difficulties. Consider the gas separation problems, and estimate the difference between the cost of pumping in the various proposed sizes."

As the size of casing will depend on the size hole, well-spacing and efficient drainage must be considered. The economic aspects of the problem of selecting casing of the proper size, it can be seen, hinges on a number of factors.

Welded Casing

The use of welded-joint casing is increasing. The practice first was employed on conductor pipe, but later was extended to include surface strings; the practice has been further extended to the welding of oil strings. The bell and spigot joint is widely used for this purpose. The casing is in 40-ft. joints. Two welders, starting at opposite points on the circumference of the pipe, proceed around the bell,



A cable-tool drilling outfit in West Texas driven by multi-cylinder natural gas engine. The engine has a nominal rating of 150 hp. and the unit is capable of drilling to 3500 feet

overlapping each other's bead, thus completing a two-bead weld in one trip of each welder around the pipe. As soon as a weld cools to less than red heat, which usually occurs 30 seconds after completion of the weld the casing is lowered into position for the addition of the next joint. In well work a strong ductile weld must be provided, making bond with the walls of the casing without undercutting, and have a slag, which will permit overlapping of beads without cleaning. The importance of a positive leak-proof, strong joint has led to slow progress in this branch of welding. Coated electrodes now are available, specifically designed for welding casing, that produce a dependable joint with freedom from pinhole leaks.

The need for welded joints for casing is explained by the fact that collapse rather than joint-strength limits the safe setting depth of casing of large diameter.[3] Deeper drilling favors the use of casing of small diameter, the safe setting depth of which is limited by joint-strength rather than collapse. Oil strings set at 9000 ft. under internal pressure greater than 3000 lb. per sq. in. may leak at the couplings. This is serious in a deep well. The ideal joint would be a flush joint with joint-strength of 100 percent. Only welded casing would seem to meet this requirement.

Freeing Frozen Drill Pipe

One of the serious problems occasionally encountered is that of frozen drill pipe and casing. A study made of this problem reveals the fact that stuck pipe may be freed by alternately starting and stopping the mud pump or by inducing water hammer vibration by pinching the pump suction.[4] Laboratory experiments indicate that tapping the pipe lightly while under tension may aid in freeing the pipe. The theories behind this method of freeing pipe were put to the test in the laboratory. It was found that "bridges may form in the annular space in two different manners. If circulation is stopped, solids fall through the fluid, and bridge builds upwards. If circulation is on, the solids are carried up to some obstruction, and the bridge grows downward. In a few cases decay of the bridge after circulation had been stopped would not be complete, the lower face of the bridge being sufficiently compacted to stand up. In such cases decay of the bridge could always be re-started by stopping and starting circulation a few times."

From these results sprung the suggestion that when pipe has stuck but circulation has not been lost one of the first remedial steps to be taken should be to shut down the pumps and relieve the pressure. "If after five to ten minutes this is not successful, alternate starting and stopping the pumps should be tried."

It was observed (accidentally) that although a slight jar caused the pipe to stick it also would be effective in freeing the pipe.

The second installment of *The Petroleum Engineer's* CONTINUOUS TABLES, a new feature begun in the June issue, will appear in the regular July issue of *The Petroleum Engineer*.

Drilling Mud

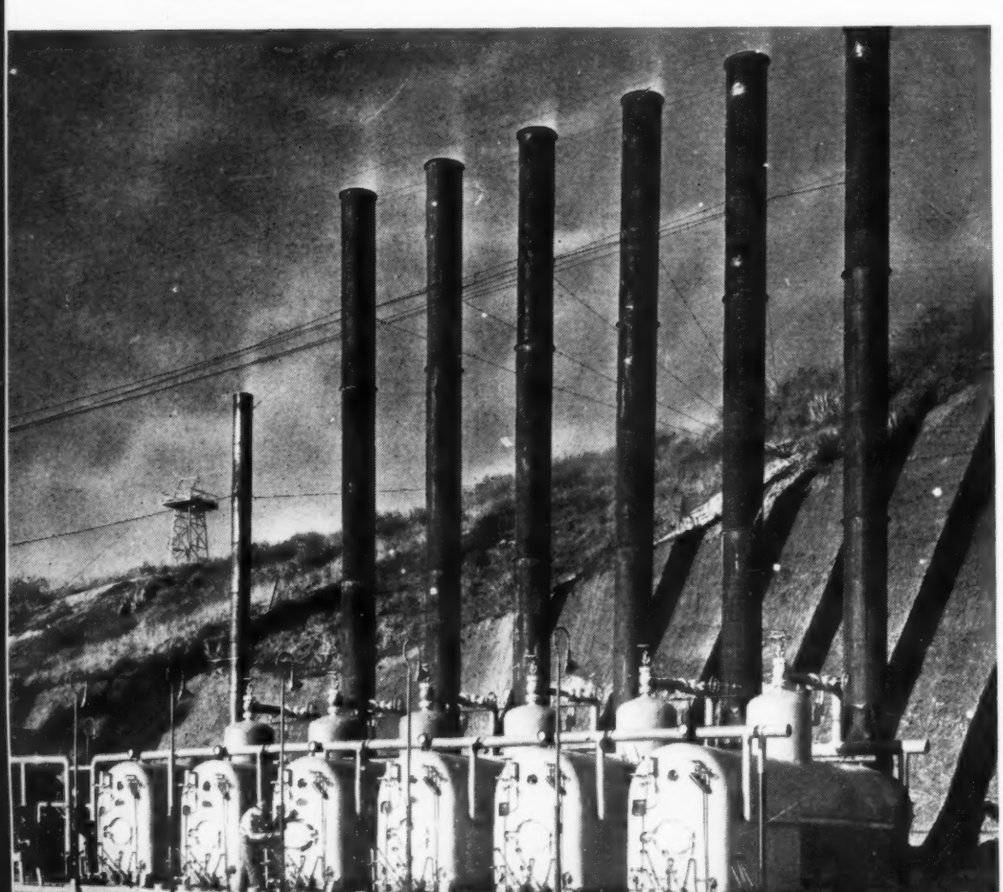
Great have been the advancements made in recent years in the utilization, treatment, and handling of drilling fluids. Standards on methods, instruments, and nomenclature for testing drilling fluids, however, never have been agreed upon despite the fact that accurate testing of muds is vital on many deep-drilling operations, particularly in the Gulf Coast fields and in high-pressure and heaving-shale areas. A tentative standard code for testing drilling fluids has been suggested.[5]

One of the most comprehensive studies ever made of drilling muds recently has been published.[6] This report can be perused with profit by anyone interested in mud-fluid problems.

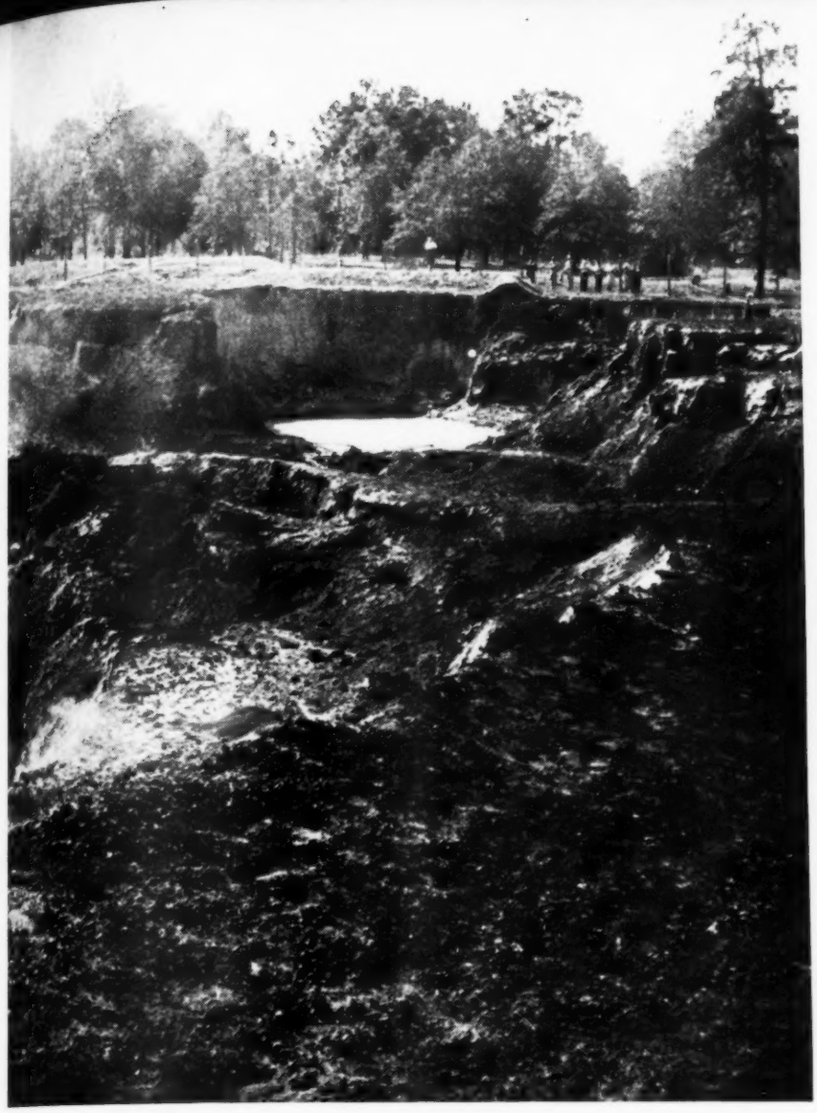
Well Control Methods

Methods of well control have undergone rapid improvement in recent years, but despite all the precautions exercised blowouts still occur at drilling wells. Control equipment is as positive and dependable as it has been possible to produce.[7] Strides have been made in the training of drilling crews in the proper maintenance and operation of blowout control equipment at the well.

It is realized that speed is paramount in a blowout and that thorough training of the crew is essential. No matter how good the equipment on a well, its usefulness is impaired unless the crew is trained regarding its proper and instantaneous use. Too much emphasis cannot be placed on this fact. Apart from the hazard to life and limb the financial loss that may result is sufficient reason for exercising extreme caution. In a discussion of the causes of blowouts[8] it is stated that normal formation pressures can be controlled with a margin of safety and blowouts prevented while wells are being drilled-in by circulating with a fluid weighing approximately 10 lb. per gallon. A field study indicates that the two principal causes attributed to blow-outs are inadequate weight of fluid column and improper



A modern installation of field boilers equipped with superheaters. This plant is on a property at Ventura Avenue Field, California



Here is seen the disastrous results of a well blowout on the Gulf Coast. Severe cratering necessitated the drilling of a relief well

consistency of the drilling fluid. Besides eliminating these hazardous factors mechanical equipment such as pressure-tested casing, fittings, blowout preventers, valves, and an ample available supply of drilling fluid are necessary. These precautions also apply to the running of casing and tubing under pressure.

Coring

Coring practices are undergoing constant improvement. Formations now may be logged electrically in open or in cased holes. Mechanical coring is increasing in importance and great advancement has been made in methods and equipment. As wells become deeper the necessity for coring increases, but the cost also increases. This is leading to the increased use of wire-line core drilling. Full-hole drill pipe is necessary in core-drilling with the wire line on deep wells. The saving in wire-line coring is accomplished in two ways: first, the wire-line cutter shoe is kept in the hole longer and digs from 50 to 150 ft. per bit; second, round trips of the drill pipe are reduced to one as against the usual two to eight trips.[9] "The necessity of using full-hole drill pipe allows a larger quantity of drilling fluid to be circulated under less pressure. This may often account for faster drilling in a well that has changed over from ordinary drill pipe."

Well Completion Practice

More attention is being paid to well-completion methods than ever before. The reason for this, of course, is obvious. In deep wells the investment is much greater and hence the exercise of care in completion becomes imperative. Controlled-pressure drilling, reverse circulation, acidization, gun-perforation, drilling fluid, drill-stem tests, the electrical logging, coring, sidewall sampling, temperature records, and other bottom-hole test data as pressure, temperature, character of the oil, and from the cores porosity, oil and water saturation, permeability, and net sand percentage of the producing horizons, all are given consideration in some degree in completing wells.[10]

Portable Drilling Rigs

Competition has forced the contractor to the utmost economy in drilling. This appears to be particularly true on wells that do not exceed 4000 ft. in depth.[11]

Portable drilling units for both shallow and moderately deep drilling have undergone vast improvement. This accounts for their increasing popularity. Most of them are driven by internal combustion prime movers. Cable-tool drilling rigs of the portable type have also been vastly improved. Cable tools are still the preferred method of drilling in many areas. Improvements in cable-tool drilling in recent years can be ascribed to the use of superior alloy steels in the manufacture of tools. For certain types of drilling in very hard cavernous limestone that is likely to give trouble by loss of circulation, cable tools have a definite application.

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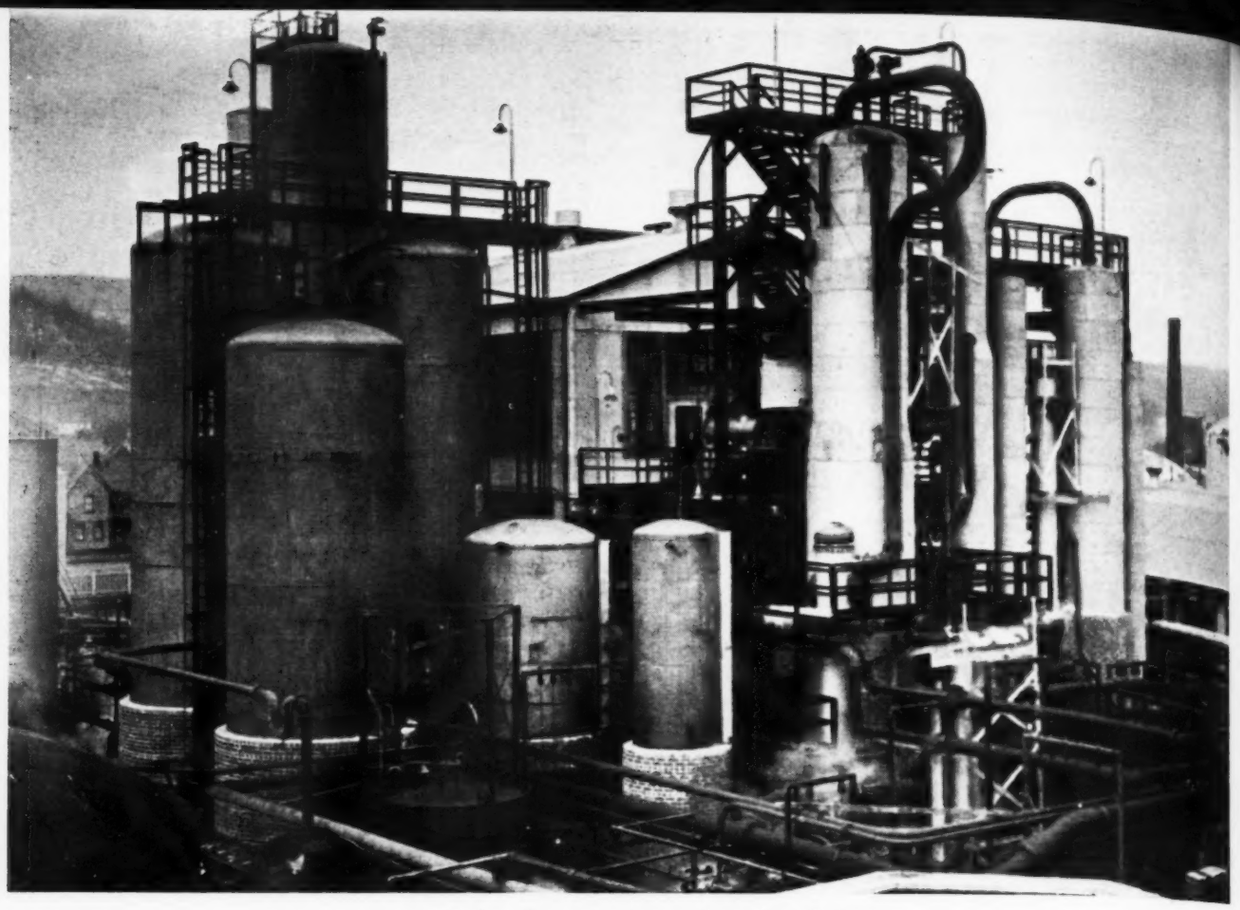

Modern benzol-acetone dewaxing plant

Progress and Trends in Refining of Lubricating Oil « « «

By GEO. F. FITZGERALD

During the past year solvent refining methods have had a widespread application as a means of producing motor oils of the high quality demanded by the modern automotive engine.

THE rapid advances made in all branches of applied science have their counterpart in petroleum refining. In 1931 Dr. A. E. Dunstan[1] said, "No more striking example of the truism that 'Modern Industry is Applied Science' could be cited than the petroleum industry of today." If this statement could have been made with justice six years ago, how much more emphatically could it be repeated now.

Not so many years ago the art of manufacturing lubricating oils was simple and direct. Customer requirements were not strict and a small line of oils would satisfy a wide market. It did not seem to matter whether an oil was paraffinic or asphaltic. The refiner merely had to stock up with a slightly filtered neutral oil and a fairly good bright stock from which he could blend all the grades of automotive lubricants anyone thought necessary. Some heavy cylinder oil and a thick gear grease completed the setup. Most people put up their cars for the winter so there was little need for thorough dewaxing. Industrial and heavy machinery lubrication likewise was in an undeveloped state. A few standard types of compounded and straight mineral oils were considered sufficient for what is now one of the most exacting markets.

Equipment requirements were correspondingly simple and few refiners expected to discard any of it as junk until it was worn out. Today it is different. Processing equipment is evolving so rapidly that new installations are hardly completed before improved designs are available. The refiner cannot afford to "wear out" his equipment; he must keep replacing it with more efficient types. The result is that the petroleum industry has an obsolescence rate greater than that of any other industry[2].

In planning new equipment the trend has swung conclusively to the purchase of pre-fabricated units from engineering companies who are specialists in their particular field. This policy is dictated by reasons of economy, efficiency, and safety. The equipment engineers are in a position to satisfy a refiner's exact needs much better than his staff engineers could with their necessarily limited experience. The day of the "home-made" unit designed and built by the refiner's own personnel is practically done.

In connection with process changes

and the purchase of new equipment it has been suggested[3] that the refining industry recognize the necessity of such changes and more generally adopt a system of charging off the costs in a manner analogous to that of the automobile manufacturers.

These remarks are particularly true as applied to refining of lubricating oils. After the introduction of centrifugal dewaxing the old cold-settling process practically disappeared. Now with the adoption of several commercial processes for solvent dewaxing, expensive batteries of centrifuges are standing idle. These same solvent dewaxing methods themselves have undergone extensive improvement since their introduction. Each new installation provides an opportunity to apply a new development. The dewaxing units constructed[4] in the past year have incorporated the latest features of continuous mixing and ratio-flow control. Direct-expansion ammonia and counterflow exchange have supplanted the older brine systems. Improved pressure and vacuum filters permit using an insulated filter shell instead of cold rooms. The solvent recovery systems have been improved to give more thorough stripping and easier operation. Since the total capacity of the dewaxing units now completed is estimated as sufficient to handle 50 percent of the motor oil demand active construction for the next few years is indicated[5].

Pour-point depressors are in common use today but their cost must be balanced against dewaxing costs that are declining as the new processes gain in efficiency. Dewaxing has the additional advantage that it produces oils with cloud points substantially below the pour point. Cloud point is being regarded as important for its effect on sales. There is a definite consumer objection to oils that appear cloudy in dispensing bottles at temperatures above freezing. The solvent dewaxed oils with their low cloud points escape this criticism.

As more units are completed and further experience gained, construction costs will be lowered and design and operating conditions simplified. The increased yields of oil will lower costs by conserving stocks. Many refiners who have accumulated unpressable distillates or slop cuts that resist centrifuging now have a means of converting these dead stocks into salable products.

The conservation of lubricating stocks is becoming increasingly important as the use of solvent extraction is extended. As with solvent dewaxing, the potential market for extraction units is estimated as only 50 percent saturated. The response of the petroleum industry to these new methods is indicated by the number of completions. Today there are available 28 commercially practicable processes that were not in use five years ago[6]. Of the 54 units in operation 22 are dewaxing plants and 32 are extraction plants. The majority of the former are of the benzol-acetone type. The propane process comes next with five units in operation. The fourth propane dewaxing and deresining plant built in this country was completed early this year and is the first to operate on Pennsylvania charging stock. In number of installations the Chlorex process heads the list for solvent extracting with Duo-Sol and Furfural competing for second place. The difficulty of recognizing the importance of a new idea is illustrated by what happened when in 1929 a Furfural-treating process was proposed[7] to a leading oil company. The reply was that they were not interested in solvent refining and the use of Furfural was impractical.

One of the developments being awaited anxiously is the countercurrent tower for continuous solvent extraction. In theory this is the ideal method from every angle. Contact is more thorough with less danger of emulsification; the effect being that of an infinite number of stages. The degree of treat should be controllable with accuracy over a wide range. Concentration of control equipment on one unit instead of four or more treaters will simplify operation. That a great many other developments are due may be judged from the common belief that by the end of this year there will be in commercial use more than 50 new processes that were not anticipated in 1932.

Solvent extracting and dewaxing are the accepted means for manufacturing high-quality automotive lubricants but much work yet must be done to determine the optimum degree of treat. Over-refining not only removes the polar compounds that apparently produce oiliness but also the oxidation inhibitors. Addition agents are being developed to correct over-refining and impart new qualities as well. It is apparent[8] that the application of even paraffin oils to the severe conditions of aviation service has reached its limit. Heretofore the paraffinics have supplied the only acceptable lubricants for aero motors but, with the tremendous increases in power likely to be adopted, no natural oil will be suitable. The industry will be obliged to supplement the work of subtractive refining by means of addition agents. Compounds have been added to depress the pour-point, to raise the viscosity index, and to improve lubricity but they are not entirely satisfactory and vital improvements are required. With the proper addition agents and a correctly refined base it should be entirely practical to formulate a lubricant for any requirement.

In this connection a word should be said for Diesel lubrication. Aircraft motors and Diesels differ radically in the matter of cycles, fuel injection, and ignition, but the lubricating problems they present are much alike[9]. Aircraft motors operate almost entirely at full load and develop temperatures and pressures comparable to Diesels. Both types of motor require lubricants of high oiliness and film strength. Extensive adoption of high-speed Diesels for automotive transportation would involve major alterations for filling station facilities and processing equipment in refineries. Refiners hesitate to begin such a program and are sparring for time to consider all angles.

The day of synthetic lubricants doubtless is coming but by no means

General view of a refinery, showing the white tower of a stabilizer in the center of the picture with dismantled steam stills at the left. The stack and twin towers of a modern pipe still are seen in the right background

An old shell still battery being torn down to make room for new equipment

is at hand. Addition agents are needed that will fulfill their functions without breaking down either in storage or in use. Even more intensive research must be directed toward obtaining accurate knowledge[9] of the factors influencing the action of solvents on oil. With the rise of synthetic lubricants, hydrogenation and polymerization will gain new importance. Hydrogenated gasoline[10] cost 20 cents a gal. at first and now a price of ten cents a gallon is said to be sufficient to net a profit. Similar advances possibly may be made in producing hydrogenated lubricating oils. Lubricants of exceptional quality[11] with a very high viscosity index, low carbon residue, and high resistance to oxidation can be produced by the catalytic polymerization of the high-olefin fraction of cracked gasoline. These achievements indicate that the petroleum industry is approaching a new field of endeavor in which crude may be used as the material for the manufacture[12] of chemicals to be used in making solvents, plastics, and rubber substitutes. Catalysts will be of the utmost importance in the future development of a synthetics industry. Even now many laboratories are engaged exclusively in developing catalysts for promoting or controlling hydrogenation, polymerization, cyclization, and alkylation.

Efforts continually are being made to improve filtering efficiency and filter clays. The types of activated earths are increasing and to their number have been added a specially-treated bauxite and a synthetic magnesium silicate. These two new filtering mediums are attracting considerable attention. The first because it may be reactivated to 100 percent efficiency and the second because it permits contacting in solution at relatively low temperatures thus making a furnace unnecessary.

The new solvent processes with their more accurate control, increased yields and applicability to a wide range of stocks have threatened to eclipse sulphuric-acid-treating, the standby of the petroleum industry almost from the beginning. Instead of giving up without a struggle, the advocates of acid-treating have been modernizing their methods of applying acid to oil. The results they have achieved provide an excellent example of the beneficial effect that new competition may exert upon an old-established process. Substitutes for oleum treating have been offered from time to time in the past but they never attained very great commercial success. Consequently the batch system of acid treating with air agitation remained practically unchanged until recently. Modern engineering now has applied centrifuge separation and mechanical mixing and proportioning to acid-treating, thus restoring much of its lost prestige.

In order to follow the trends in petroleum refining it is necessary to study the influence of industrial growth. Oil is an important factor in almost every new industrial or commercial development. The increased demand resulting from these new outlets explains the rapidity of recovery and the actual surpassing of previous peaks. This increase is here shown:

LUBRICATING OILS
Demand in Bbl.

Year	*Domestic*
1936 - - -	22,676,000
1934 - - -	18,484,000
1932 - - -	16,614,000

Of all industries the one having the greatest effect on refining unquestionably is the automotive. The cars manufactured by only a few companies provide the greatest single market for petroleum products. It is recognized that the oil industry could not have attained its present magnitude without the motor car[13]. It follows, then, that those factors influencing manufacture and design of automobiles also will react upon the oil-refining industry. That such is true readily can be seen. Public opinion has dictated the change to lower, faster, and lighter cars with smaller, more economical motors. The smaller motors require lubricating oils of lighter viscosity and even greater resistance to oxidation. The increased speeds put additional loads upon the motor oil, thus requiring the refiner to produce not only lubricants with lighter body, but also with a quality exceeding anything previously manufactured. Lowering the height of the cars has brought into common use the hypoid gear rear axle, one of the most vigorously discussed changes in motor cars and one of the stiffest lubricating problems ever handed to the oil industry.

These typical innovations did not appear overnight. The trends are really slow-moving but too frequently are unrecognized until the accompanying problems have become unmanageable. Those factors affecting lubrication can be charted and the trends analyzed far enough in advance to permit production of the required lubricants. That engines were going to be built calling for lighter and lighter lubricating oil was evident at least a year before such oils were absolutely necessary. The trend was seen by a few refiners who began marketing the required grades but the majority failed to notice it. Considering the importance of the automotive market, the wisdom of adjusting refining processes and equipment to the changing requirements introduced by progress in car design readily is apparent. That car manufacturers actually are compelled to introduce new designs is seen by the fate of those few concerns that tried to stabilize their products. The automotive industry cannot become static if it is to continue in business and by the same reasoning the petroleum industry must bring out new and better lubricants.

The new bearing metals developed for these smaller motors at first presented a serious lubrication problem that has been successfully solved in the past year. The unfavorable reaction be-

tween these metals and some of the highly-refined oils has been overcome either by modifying the refining process or by the use of inhibitors and stabilizers. Here, as in numerous other instances, the answer to the problem was reached by close cooperation between automotive and refining engineers[14].

With the present widespread adoption of the hypoid gear has come the realization that conditions may arise where even the best normal mineral oil is incapable of handling the load. Power output and performance demands have so increased unit pressures on rear axle gears that straight mineral oils tend to fail under severe service. A solution to the problem has been approached by developing E. P. lubricants. Such lubricants to be effective must be suitable[15] for general purpose application and for replacement of mineral lubricants, resistant to oxidation, non-abrasive, and non-corrosive. They must form a resistant film on the gear teeth to prevent welding or scoring. They must be unaffected by age or exposure to heat or cold. They should be water insoluble and no precipitate should form on standing. The importance of E. P. lubricants may be seen from the fact that in the past three years practically every car manufacturer has serviced at least part of his line with E. P. at the factory.

The refiner who desires to make E. P. lubricants soon will discover that there is no exact specification for them. There are several factory testing machines available but they do not agree among themselves. An oil that passes on one machine may fail utterly on the next. Road tests are the only effective method of evaluation. It is in this way that manufacturers have established that common E. P. lubricants are not safe for hypoids under maximum load conditions. The hypoid with its bevel pinion set below the center of rotation of its ring gear permits lowering the drive shaft and thus lowering the car. This same off-center setting, however, is the reason why lubrication is so difficult. The gear teeth are subjected not only to pressure but also to a wiping action. Ordinary mineral oil and mild E. P. lubricants fail under such conditions. The case calls for activated E. P. lubes, that is, special hypoid gear lubricants that will coat the gear teeth with an adherent film that prevents metal to metal contact under all conditions. The best type so far developed contains lead soap and active sulphur. It is not sufficient, however, to mix lead soap, sulphur, and mineral oil and call it hypoid gear lubricant. The constituents must be combined under carefully controlled conditions[16] or failure is certain. It is important to note that the activity of the hypoid lubricant diminishes in use due to oxidation and the rear end must be drained, flushed, and re-filled every 5000 to 6000 miles. It is not sufficient to make up losses.

It is indicated today that cars will be lower in the future[17]. The trend will progress from hypoids to worm drives with operating conditions vastly more severe than those now encountered in our latest rear axles. Here is a clear-cut example of "coming events casting their shadows before." The present confusion over proper lubrication for hypoids will be repeated when worm-gears come into common use unless the petroleum industry recognizes this trend and prepares to meet the accompanying difficulties. In view of the present puzzle over hypoids it may be expected that worm-gear lubricants will necessitate using all the available time for research and development if they are to be in production when a demand arises.

Consideration of these specialized lubricating problems leads naturally to transmission lubricating questions. Gear sets are being made smaller each year and at the same time important innovations are being incorporated. Synchro-mesh has become almost universal and over-drive is gaining rapidly. Automatic shift is now well established with a General Motor car very recently entering the field with a thoroughly-tested device. It is freely predicted that all cars eventually will come to some type of automatic shift. These advancements increase the ease and comfort of driving but in an even greater degree they multiply the problems of the lubrication engineer and the refiner. Smaller gear-sets mean smaller gears with consequent increase in unit pressures. The other devices complicate matters, for example, the automatic shift requires low-viscosity lubricants in cold weather. The old, heavy "gear grease" is very rapidly disappearing in favor of a specialized lubricating oil compounded to meet a particular situation. In the words of a prominent motor executive[18] in referring to hypoid lubricants, ". . . for the first time in automobile construction, a lubricant has become a mechanical part designed to fit."

The automotive men feel that the petroleum industry does not fully appreciate or accept the meaning of this quotation. That both industries could gain by closer cooperation is plain to be seen. The very dependence of each upon the other makes it imperative. The market created by the automobile has made the petroleum industry what it is and the automobile as we know it would be an impossibility without petroleum fuel and oil. Cooperative study of problems, both present and future, is the surest means of attaining the best solutions. The new 1937 cars are bringing up new problems that are the forerunners of even greater lubricating difficulties that must be faced. What the future will bring can be provided for by analysis of the trends in automotive design. These trends will indicate what future lubricating conditions likely are to be. With this much advance information enough experimental and development work can be initiated to put both industries in a position to satisfy the majority of new demands as they arise.

That cooperation between these two great industries has been successful in the past is evident from the problems already solved: crankcase dilution, crankcase corrosion, gum and anti-knock, vapor lock, cold starting, and lubricants for the new bearings. Such efforts, if continued, not only will keep these problems in check but help to solve new ones as they appear.

With lubricating problems increasing in number and complexity, refining practices have undergone a marked change. Highly technical operations and processes are supplanting the rule of thumb methods that were the mainstay of all veteran oil men. Today the accumulated experience of, say, a quarter century of refinery operation is of little avail in smoothing out the wrinkles in a solvent dewaxing or extracting unit. The past ten years have seen a concentration on the physical phases of petroleum engineering practice. Every effort has been made toward improved methods of heating, more exact fractionation, heat savings by exchange, and the perfection of continuous processes. The trend is now toward chemical technology[19] with the employment of hitherto foreign treat-

Another view of an old shell still battery being dismantled

ing agents and solvents. We may confidently look forward to at least as great advances in petroleum chemistry as we have seen in the physics of petroleum refining.

To achieve such results the industry must have a vast amount of new physical and chemical data. With our comparatively gross ignorance of the true composition of crude, real chemical refining must await the research scientists. Existing knowledge of the properties of petroleum is based on analysis of fractions that are in themselves mixtures of large numbers of chemical individuals. It is vital that a way be found to identify these individuals and to prepare large enough samples so that their properties may be determined. Such a program would involve a vast amount of work but the benefits to be gained are worth the cost.

Summary

Since 1930 the lubricating oil refining industry has undergone revolutionary changes. In the past year they have had their greatest effect with the widespread application of solvent refining methods. These new processes have been the means of producing motor oils of the high quality demanded by the modern high-compression, high-performance automotive engine. Oils for this service now are available everywhere. They have excellent properties with regard to cloud and pour tests, oxidation resistance, non-corrosion, low consumption, high viscosity index, and low carbon residue. Many operation and design problems have been remedied with further improvements in sight.

New features, such as hypoid gears and new type bearing metals, have complicated the lubricating situation. Research in new fields has advanced our knowledge of these problems. The development of addition agents has brought nearer the day of the synthetic lubricant. Major modifications in automotive and other machinery have made it obligatory for refiners of lubricating oils to keep in touch with these trends and prepare to supply the indicated lubricants as the need arises. To this end the purchase of new refining equipment must be planned for the future even as car manufacturers budget their re-tooling to accommodate new models. Closer cooperation between refiners and automotive engineers is seen as the only proper approach to new problems. Many benefits are to be gained by working together, as proved by the results of past joint enterprises.

Refiners are adopting the policy of purchasing completely engineered equipment from specialists in contrast to the older leaning toward "home-made" units. Methods of distillation, filtration, and acid treatment are responding to the cry for modernization with improved operation and control set-ups.

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Carbon Black Industry Continued to Expand in 1936

THE carbon-black industry experienced another record-breaking year in 1936, states the Bureau of Mines, Department of the Interior. New highs for production, domestic sales, and exports were established. Production was 411,345,000 lb., a gain of eight percent over the peak reached in 1930, and 17 percent more than 352,749,000 lb. in 1935. Demand totaled 467,736,000 lb., a gain of 21 percent over the previous peak of 1935. Stocks at the plants were reduced materially, reaching approximate working levels at the close of the year. Stocks reported on hand December 31, 1936, were only 79,582,000 lb., the lowest since 1928, when 50,240,000 lb. were reported. Prices remained remarkably uniform throughout the year, the average plant value rising only .02 of a cent a lb. to 3.92 cents, while the average export value remained at 4.69 cents a pound.

An increase in production of carbon black in Oklahoma and Wyoming was offset by a decline in Louisiana. This means that as the output in the Breckenridge district of Texas probably showed little change the 60,000,000-lb. increase in the national output approximates the gain in the Texas Panhandle, which accounted for nearly 80 percent of the total production in 1936. Although the paramount position of the Texas Panhandle was strengthened in 1936, the tendency to restrict "stripper" operations in that area, combined with the rise of Oklahoma as a producer, indicates that the movement of the center of production toward the Panhandle has ceased or may do so in the near future. The number of plants operated in 1936 remained 54, the same as in 1935. A loss of three plants in Louisiana was balanced by the addition of two in the Panhandle and renewal of operations of one in Oklahoma.

There were 283,421,000,000 cu. ft. of natural gas burned at carbon-black plants in 1936 compared with 241,589,000,000 cu. ft. in 1935. The total for 1936 represents about 13 percent of the estimated gas consumption in the United States, the same as in 1935. The average yield of carbon black per M. cu. ft. was 1.45 lb., compared with 1.46 lb. in 1935 and 1.43 lb. in 1934.

Sales of carbon black by manufacturers to brokers and consumers rose from 387,536,000 lb. in 1935 to 467,736,000 lb. in 1936; of the latter, 313,018,000 lb. (67 percent) were sold in the United States and 154,718,000 lb. (33 percent) exported. Of the domestic sales 278,018,000 lb. (89 percent) were consigned to rubber companies, 17,787,000 lb. (6 percent) to ink companies, 6,914,000 lb. (2 percent) to paint companies and 10,299,000 lb. (3 percent) to companies producing miscellaneous products. These data indicate a continued increase in the importance of the rubber industry as a market.

Exports of carbon black totaled 154,718,398 lb. compared with 142,184,802 lb. in 1935, and 152,286,178 lb., the previous peak of 1933. The United Kingdom continued to be the leading customer, while France and Germany again exchanged rank in second and third places, respectively. The total value of exports in 1936 was $7,250,704, compared with $6,673,016 in 1935.

General view of line being laid by the "stove-pipe" method

Developments and Trends in Pipe Line Construction and Reconditioning Practice

By FRANK H. LOVE

THE past year has witnessed its usual quota of advancements in pipe line construction and reconditioning practices. These developments have been in the nature of gradual, rather than radical, changes, and for the most part are the outgrowth of difficulties encountered in the field for which a solution had to be found. The laying of each new line is accompanied by certain interesting factors and quite often the method employed in solving a problem is the beginning of what in time becomes standard pipe-line practice.

These advancements, too, merely may be improvements to existing equipment or methods of procedure, or the more widespread adoption of known practices. Recently the Magnolia Pipe Line Company constructed a line through the "hot" soil area of South Texas. To determine the extent of coatings and wrappings to be applied to the pipe soil tests were made over the entire right-of-way.[1]

Though soil analysis is not a new procedure, its use for testing the entire route of a line is not general practice. The method employed in this instance involved the making of tests at regular intervals while the right-of-way was being surveyed, a Sheppard cane first being used to determine the resistance of the soil. Readings were taken on an average of every 200 feet. Soil samples then were obtained at pipe depth at intervals of approximately a quarter of a mile. These samples were taken to the field laboratory and tested for their degree of acidity or alkalinity, the saturated resistance determined, and a Corfield nipple test run. A pH electrometer was employed for measuring the acidity or alkalinity of the soil, and the saturated resistance was determined by use of a Wheatstone bridge.

In making the Corfield test for finding the corrosivity of the soil, nipples of ¾-in. diameter were cut from standard pipe, ground and buffed to remove all mill scale, then numbered and weighed. After placing a rubber stopper in the end of the nipple it was then placed vertically in a pint can, the stopper serving to insulate the nipple from the container. One nipple was placed in each can, and around the former was packed a saturated sample of soil. The cans were placed in a rack and a 6-volt battery connected across from the nipple to the can, the former being positive. After remaining in circuit for 24 hours the nipples were removed, cleaned, and weighed. Loss in weight and the type of corrosive action on the nipples were recorded. From these data the protective covering to be given the pipe was determined.

Another operating trend during the past year has been the more extensive application of pipe line coatings in central plants rather than on the job.[2] The equipment quite frequently is portable so that it can be moved from place to place and the plant set up where most convenient to the construction work. The advantage of this method is the elimination of inefficient field application, wastage of coatings, and loss of time that may be occasioned by bad weather, etc. The pipe is coated and wrapped by machine, as a rule in a single operation. An exception was the practice followed recently in coating the pipe for a line laid in the vicinity of Palmer, Kansas, by the Northern Natural Gas Company.[3] In this instance hot enamel only was applied in the central plant, the wrapping later being applied in the field. No damage occurred to the coating as a result of handling and transporting to the field from the yard, as the trucks for stringing were equipped with padded cut-out saddles for supporting the pipe.

The usual procedure in coating pipe in a central yard is first to free the surface of rust or any foreign matter that may have collected enroute from the mill. The priming coat is then sprayed on, putting it in readiness for the coating and wrapping machine. On one type of equipment a series of tables and rubber rollers feed the pipe into the machine. The hot enamel is flowed onto the pipe from overhead outlets, the surplus returning to the machine pot for recirculation. The required number of coatings and wrapping of

the pipe are accomplished in one passage through the machine.

During the year the "stove-pipe" method of laying pipe lines has been used more extensively than ever before.[4] Devised originally for laying pipe under rough or muddy conditions that did not permit of firing-line welding, this procedure now is used quite extensively in the construction of short lines. It is slower than firing-line welding and thus is not suited for the laying of long lines, but has advantages on short systems. As mentioned, it is possible to use this method under conditions where firing-line welding could not be employed, and it effects certain economies, as it eliminates the line-up crew. Briefly, in constructing a pipe line by the "stove-pipe" method, the procedure is to line the pipe up on skids above the ditch, a single joint at a time. A tack weld is made, then the welders finish the joint, the pipe remaining stationary, whereupon the welders move on to the next joint.

Reconditioning Practices

Reconditioning of pipe lines yearly becomes more and more standardized as to procedure. Reconditioning practices can be classified under two general headings: (1), field reconditioning, and (2), reclamation in central plants. When it is impossible to take a line out of service for any considerable length of time it is obvious the former method must be adopted. Quite often, however, a line no longer needed in a certain location is taken up, reconditioned, and the pipe used in laying a new line on the system; or, as was done recently, a line that originally had been constructed for the transportation of oil had been in use for a number of years as a gas transmission system, and now again was to be used as an oil line, making it necessary to put it in condition for the latter purpose. Under circumstances such as these the pipe can be hauled to a central yard or a number of yards conveniently situated, this method seemingly being favored where its use is practicable.

Regardless of the reconditioning method eventually employed the preliminary step, that of locating the bad areas, is the same, except of course, when an entire line is to be moved to a new location, in which event all the pipe naturally is inspected. A variety of methods are used to determine corroded and otherwise bad areas of pipe: (1) from leak records, (2) soil tests, (3) the digging of bell holes, (4) special electrical equipment devised for the specific purpose, and, (5) observation of the physical conditions of the terrain.

Soil tests, in the past, have been used more as a guide to coating applications on new lines than as a means of locating areas of pipe to be reconditioned. This has been particularly true in the Mid-Continent, but now one major company, with an extensive reconditioning program underway in Oklahoma is employing this method. The soil test used is the same as that discussed more fully above under pipe line construction methods. An interesting sidelight on this work, however, is the fact that in the areas where the work is being carried on a suitable location for setting up the laboratory could not be found, as a consequence the company has ordered a specially-constructed portable laboratory, mounted on a truck chassis. In this manner the laboratory can be moved from place to place, rendering it convenient to the work at hand at all times. When a bad section of pipe is found the line is uncovered with a ditching machine in both directions until good pipe again is found.

Central Reconditioning Yards[5]

Pipe to be hauled to a central yard for reconditioning usually is torch cut into joints of approximately 20 ft., removed from the ditch by means of tractors equipped with a winch, and loaded onto trucks. Upon receipt at the central yard the first step usually is to straighten all crooked pipe with a pipe-straightening machine. The pipe is then given a general classification and placed on racks. The best stock can go immediately to the cleaning machines, but pipe with leak clamps, half soles, sleeves, etc., attached are placed on a certain rack and these removed. Otherwise they will not pass through the cleaning machine.

The latter are of the stationary type and can be adjusted to handle a wide range of pipe diameters. These machines are powered by internal combustion engines, and cleaning is accomplished by a series of toothed cutter wheels, and steel-wire brushes, rotating about the pipe. For the removal of old coating material from pipe a special head, which involves the use of a series of knives, can be attached. The speed of the machines can be varied, so that pipe in the worst condition can be run through more slowly than the better stock. The machines also can be put in reverse, as quite frequently a joint of pipe is in such a bad state it is necessary to run it through the cleaning equipment several times. Even then, when pits are especially deep, all rust is not entirely removed. For the removal of rust from deep pits some companies employ sand blasting, others heat the badly-corroded sections with an acetylene torch and dislodge the material by pounding the pipe with a ball peen hammer.

A thorough inspection is given following cleaning, and depth of pits measured, etc. The inspector indicates what repairs are to be made. Sections too badly corroded for further use are cut out and discarded. Some companies have adopted a policy of making repairs only by spot welding, using no

Coating and wrapping pipe in a central plant

A traveling-type cleaning machine used in reconditioning pipe lines in the field

patches or half soles. Others sometimes utilize the two latter methods on limited areas.

On one project of the past year a more extensive use was made of grinding smooth spot welds. By grinding down the welds with pneumatic grinding wheels likelihood of puncturing coatings subsequently applied was avoided, and it also permitted of more ready inspection of the welds for detection of pin holes and other defects.

Beveling of pipe ends, and removal of threads, in instances where the pipe is from a screwed line, also form a part of the procedure before the pipe is ready to be given its final classification. Grading of pipe by the several companies, while not according to one standard classification, has a common objective, that of salvaging as great an amount of pipe as possible, and utilizing it where it will serve to greatest advantage.

The Standard Oil Company of California employs plant reclamation methods that differ in certain respects from those employed by others.[6] The principal differences are these: The large diameter pipe of the first class are torch heated internally to remove oil residues and any protective coating. From this heating rack the pipe is carried through a furnace by a roller conveyor. The furnace is enclosed and the pipe travels over high-pressure burners, with a temperature of approximately 1300 deg. fahr. maintained. The pipe then is transferred to a blast rack where all rust and other products of corrosion are removed.

Field Reconditioning

Repairing lines in service and reconditioning long lines without shutdown are usual practice.[7] Extensive projects can be completed successfully with pumping continuous, except in rare instances when a section of pipe must be replaced or when a break occurs. The latter is uncommon, however, as the pipe is handled carefully both in raising and lowering. The most generally accepted equipment for this purpose are manually-operated ratchet jacks. These hoists are lightweight, easily moved about on the job, and lower and raise pipe in a steady manner, avoiding whipping or rough handling that might result in breakage to the line. Lifted from the ditch, the pipe is placed on skids to await the traveling-type cleaning machines. The latter are equipped with the conventional cutter wheels and steel-wire brushes that rotate about the pipe as the machine moves forward, removing scale, dirt, etc. A special head can be attached for removing old coatings. A late model machine of this type is powered by a single-cylinder air-cooled engine, revolving the cleaning head around the pipe at a speed of 110 revolutions per minute. The forward speed of the machine ranges from two to 50 ft. a minute, depending upon the condition of the pipe and the degree of cleanliness desired.

With the pipe thus cleaned the inspectors then are able to locate pits, bad collars, and leaks, and mark them for repair, either by spot-welding, patching, half-soling, or other means. Sharp-pointed tools are employed to remove rust from pits that the machine cannot reach. Collars and flanges found sweating are burned out with an acetylene torch and welded on both sides. Caulked collars in some instances are repaired by welding on steel covers molded to fit them. The line thus being repaired another traveling-type cleaning machine, a smaller one in this instance, is passed over the line as many times as required to clean it completely. Prior to the application of protective covering the pipe is washed with gasoline.

One company in California follows a policy different in some respects from the procedure just outlined. This company, on some portions of its system, has several lines in the same ditch. These lines are uncovered, raised by hoists, and wooden blocks placed beneath them. Thus raised free of the soil a complete inspection can be made. Coating is removed from the pipe by sharp-edged scrapers, and following the crew handling these instruments come the sand-blasting equipment. The upper half of several joints are cleaned in continuous operation, bad spots then being spot-welded or patched, as may be required, and the primer coat applied. The pipe is then rotated and the lower side of the pipe reconditioned in the same manner.

In the case of gas lines a somewhat different procedure must be followed, as the highly inflammable nature of the gas makes it impossible to recondition a line that is in service. Consequently the practice is to weld up a section of pipe, usually about two miles in length, shut off the gas and tie-in the replacement. This can be accomplished with minimum shutdown time. The pipe removed from the line is transported to a central yard, reconditioned, and returned to the job, itself to serve as a replacement section. The operation is continued until the line is completely reconditioned.

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Progress and Trends in Pressure-Control Drilling and in the Application of Bottom-Hole Chokes

By H. C. OTIS[1]

Pressure-control drilling almost standard practice in certain fields—Besides their application to eliminate freezing, bottom-hole chokes now are employed to reduce emulsification and lower gas-oil ratios—Blank removable chokes for shutting off flow in tubing or casing, a significant development that has far-reaching possibilities

DURING the past year operations on wells under pressure, or against closed well pressure, have increased many fold over those of any other previous year. This sudden increase is due largely to the rapidly-mounting number of rotary completions made under pressure control, with accompanying running and pulling of drill stem and tubing under pressure, but also is due somewhat to new applications of removable bottom-hole chokes.

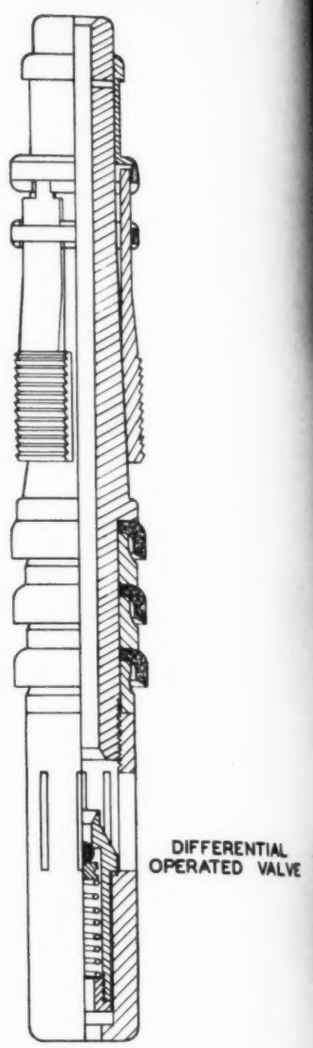
Drilling-in under pressure control has become a comparatively standard operation for many of the producing companies in the Fitts, Jesse, Crescent, Moore, Edmond, Orlando, Billings, and Oklahoma City fields of Oklahoma, and in the several fields of West Texas and New Mexico. It is conservatively estimated that 75 percent of the approximately 250 completions in Lea County, New Mexico, since the beginning of 1937 have been made under pressure control.

In many respects the outstanding example of an area drilled-in under pressure is the Mansion area of the Oklahoma City field. With wells 6500 ft. deep, a bottom-hole pressure of approximately 400 lb., and a very loose unconsolidated producing sand, the operators were faced with the necessity of using some completion method that would not load the producing horizon. Cable tools were not practicable because of the nature of the producing Wilcox sand. Consequently drilling-in under pressure control was used throughout the entire area.. Although many of these wells are situated in close proximity to dwellings, to the state capitol, and in general are in an area that presented a serious fire hazard, and although many of the wells were brought in with extremely large open-flow capacities, there was not a single instance of a well getting out of control or catching fire as a result of this method of completion.

Equipment for drilling-in under pressure has undergone continuous improvement during the year. Today virtually no time is lost in making connections when drilling with outside-coupled drill stem and the customary square kelly joint, while many of the hazards that accompanied the use of earlier equipment for drilling-in under pressure have been removed. This is well illustrated by the fact that during the year some of the largest and highest pressure wells completed in Oklahoma in years were completed by this method, and without a single instance of a well getting out of control.

It has been found that the carrying of high surface drilling pressures normally is not necessary. In some areas the surface drilling pressure is controlled largely by the rate at which the circulating oil is pumped, this rate being sufficient almost, but not quite, to balance bottom-hole pressure. Drill stem diameter employed, of course, affects somewhat the results obtained. A large drill stem diameter results in a smaller annular space between it and the casing, and consequent higher velocity in the circulating medium and a greater pressure drop between the bottom and top of the well.

Drilling-in under pressure control has necessitated the running and pulling of a great deal of drill stem and tubing under pressure. This work has been successfully carried on against closed well pressure as high as 2550 lb. per sq. inch. Only one accident mars a perfect record in this type of work. In New Mexico, a section of drill stem that was being used on one too many wells, apparently collapsed under a closed well pressure of only a little more than 1100 pounds. The well caught fire before the emergency control equipment could be closed. To guard against the recurrence of such an accident, an emergency control head that, under remote control, will close almost instantly by use of well pressure, has been designed and is now being tested.



Removable bottom-hole choke, equipped with valve that automatically shuts off flow in tubing should damage to the surface connections open tubing to atmosphere

The applications to which removable bottom-hole chokes have been put during the year have been both varied and interesting. The older use, to eliminate freezing at the surface controls of high-pressure wells, has continued to grow, especially in Gulf Coast fields. The principal new application has been their use to reduce emulsification in flowing wells, adopted particularly in Oklahoma and West Texas.

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[1]Otis Pressure Control, Inc., Dallas, Texas.

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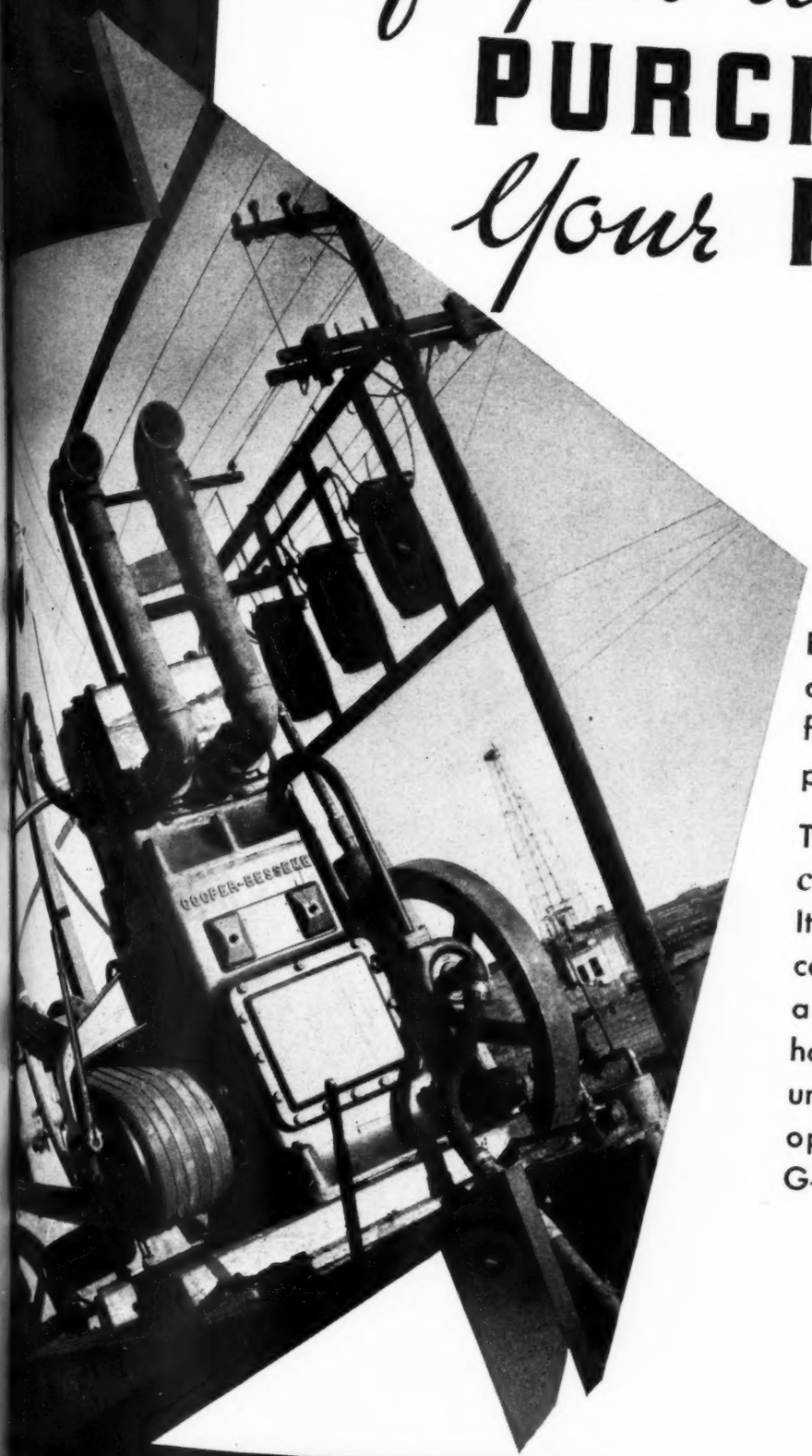

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ing is done by means of a bottom-hole choke, the temperature of the oil and water as they enter the choke is higher than is the case when a surface choke is employed. Some temperature loss undoubtedly takes place as the production emerges from the bottom-hole choke, but this temperature loss very largely is immediately compensated for by heat transfer through the walls of the tubing. The tubing itself acts as a long vertical separator under constant agitation and acted upon from the outside by the high bottom-hole temperatures. It probably is because of the above two factors that such remarkable results in reducing emulsification have been accomplished. In several instances, wells whose production had to be treated before being accepted by the pipe lines, have been made to produce clean pipe line oil. In virtually every other instance the percentage of B. S. produced has been lessened materially. Reduction in treating costs has resulted from the reduced amount of treating agent necessary, but still more by a marked reduction in the time and expense required for "rolling" and heating.

In a typical group of 12 such installations by one company in West Texas and New Mexico, the average amount of B. S. produced was reduced from 3.01 percent before the installation of removable bottom-hole chokes to 0.65 percent after their installation. The volume of water produced, however, was increased from 5.04 to 6.90 percent. The increase in water production doubtless can be attributed to the decrease in B. S. produced. The quantity of treating agent required was reduced 50 percent and the heating and "rolling" formerly required were almost entirely eliminated.

Some progress in the use of bottom-hole chokes to reduce gas/oil ratios has been made. Two extreme examples, each typical of the two conditions under which favorable results may be expected, follow:

In a West Texas well, in which production is from a tight sand carrying large quantities of free gas along with the oil, the use of a 1/8-in. removable bottom-hole choke reduced the ratios from 15,950 cu. ft. per bbl. to only 846 ft. per bbl. at approximately the same rate of oil production. The very considerable decrease in quantity of gas produced, however, was not accomplished immediately. Instead it appears that the use of the bottom-hole choke gradually caused the setting up of a fluid seal that the switcher could not disturb by inadvertently opening the surface choke too wide.

The other extreme instance referred to occurred recently in one of the deep high-pressure wells in the Moore field of Oklahoma. Due to the naturally high gas/oil ratios in the sand and the high pressures, flow velocity up the tubing was so low as undoubtedly to result in considerable slippage. It was reasoned that the use of a bottom-hole choke, by causing expansion of the gas, would so increase flow velocities as to reduce this probable slippage. A choke set at 7200 ft. caused a reduction in ratios of from 14,000 ft. per bbl. before the installation to 9,000 ft. afterwards. Nearly a month later a further considerable drop in ratios occurred, indicating the possibility that a fluid seal had been built up.

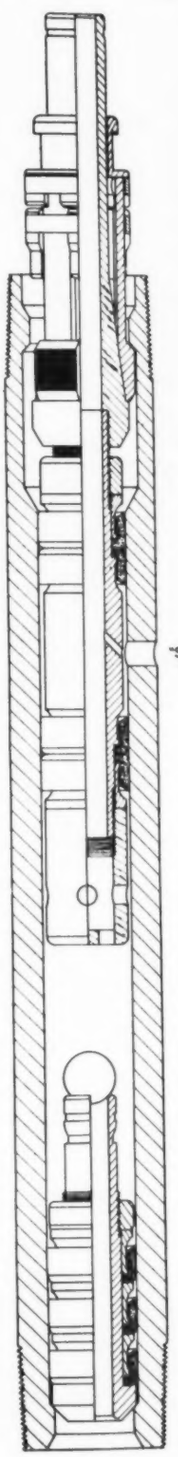
Blank removable chokes, or casing plugs, have been employed to excellent advantage in plugging casing when it becomes necessary to change surface connections. One such installation recently was made in a 1125-lb. New Mexico well. In this instance a blank choke for the 5 3/16-in. casing was run in on a 5/8-in. line to 2250 feet. A complete shut-off was obtained. To reduce the pressure drop across the choke, the casing was loaded with water from the choke to the surface.

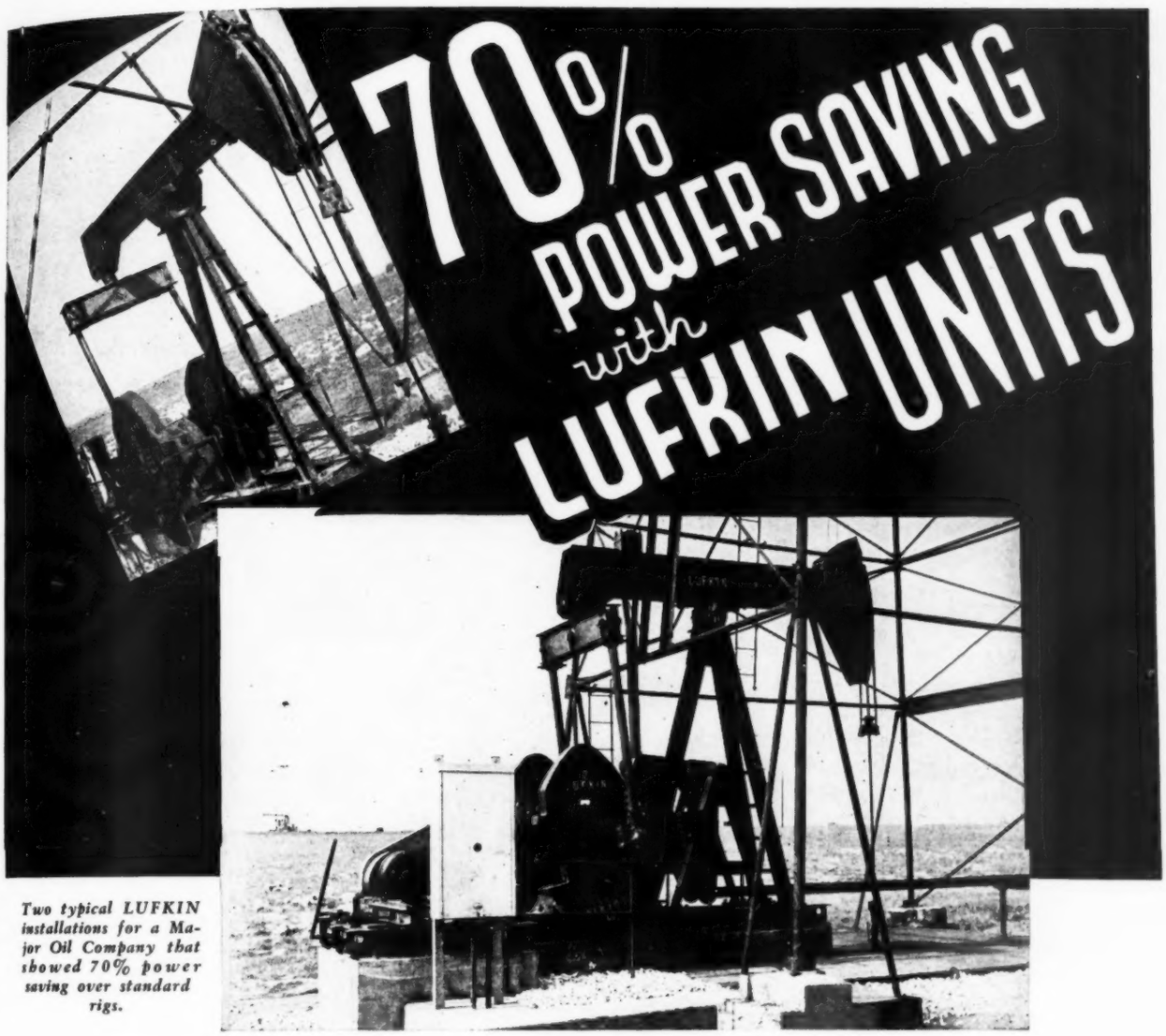
In another instance in the Moore, Oklahoma, field, it was desirable to set a blank 7-in. choke to permit changing the six casing gate valves that had been cut badly. This well has a closed surface pressure of 1200 lb., extremely large open-flow capacity, but is dangerous to handle because of the large quantities of sand produced. The blank choke was run in on a 7/8-in. line to only 45 ft. below the surface. The casing gate valves then were removed, taken to a shop for overhauling, and replaced on the well, and the choke pulled, all without any difficulty and without blowing off the well to atmosphere.

Blank bottom-hole chokes have been used for some time to plug tubing in flowing wells where there exists possibility of injury to surface connections. By substituting a differential-operated valve for the customary blank bean, as shown in Fig. 1, it is possible to equip the tubing in a well so that flow at normal rates can be carried on, but should the surface connections be injured and the tubing turned loose, the increased velocity of flow immediately will cause the differential valve to seat against the base of the mandrel, thus plugging the tubing at the depth at which the choke is set.

There have been a few interesting uses of a "side-door" bottom-hole choke introduced about a year ago. This removable choke, shown in Fig. 2, controls the admission of gas from between the casing and tubing into the tubing, while normally permitting unrestricted flow of oil from beneath. The best example of the use of such a choke is in the new field near Jefferson, Texas. In this instance it was found that the well would not flow of its own accord. The casing consequently was perfor-

Removable bottom-hole choke with "side-door" orifice, which controls the admission of gas from the casing into the tubing, at the same time permitting the flow of oil from beneath





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ated a few feet above the depth at which oil was entering the well. Such large quantities of gas were obtained by these higher perforations that the well was, in effect, turned into a gas well. A packer was run in on the tubing and set immediately beneath the perforations through which the gas was entering the casing, and a "side-door" choke was used to control the introduction of desired quantities of this gas into the tubing to flow the oil that entered from beneath the packer. Several "side-door" orifices were tried, with quite interesting results. When the side orifices employed were so small as to admit gas only at a rate that resulted in flow with a high bottom-hole pressure on the oil sand, the quantity of gas produced was found to correspond closely with the theoretical capacity of the orifices employed. When, however, the orifices employed were large enough to result in a thoroughly-aerated column in the tubing and a low bottom-hole pressure, the total quantity of gas produced was found to be far in excess of the theoretical capacity of the orifices only. The most reasonable explanation advanced is that under the latter condition considerable quantities of gas come out of solution in the oil sand, and enter with the oil.

A great deal has been accomplished during the past year in designing and using equipment for working on live flowing wells. With the increased interest in and demand for equipment and work of this nature, it is anticipated that the coming year will see even more advances than has the past year.

Germany's Crude Oil Production for First Quarter, 1937

Germany's total production of mineral oil during the first quarter of 1937 amounted to 743,918 bbl. compared to 756,329 bbl. for the first quarter of 1936—a decrease of 12,411 bbl., or less than 2 percent. Production in the Hannover fields during the first quarter of 1937 amounted to 679,252 bbl., or approximately 90 percent of the total. This was a decrease of 10,235 bbl. or approximately 2 percent compared with the same period in 1936.

Hannover production during the first quarter of 1936 and 1937 was divided among the various fields as follows:

1936	Nienhagan Hanigsen	Wietze Steinforde in barrels	Eddesse Oberg
January	187,390	29,512	14,427
February	167,062	27,139	12,222
March	209,223	28,343	14,168
	563,675	84,994	40,817

Grand total 689,486 barrels.

1937	Nienhagan Hanigsen	Wietze Steinforde in barrels	Eddesse Oberg
January	205,282	26,544	12,628
February	175,805	24,647	12,334
March	183,197	25,956	12,859
	564,284	77,147	37,821

Grand total 679,252 barrels.

The number of workmen employed in the German oil fields during March, 1937, decreased slightly compared to the preceding month. There were 4,922 workers employed at the end of March, 1937, compared to 4,954 at the end of February, 1937.

Foreign Sources of Japan's Crude Oil Supply

THE crude petroleum produced in Sakhalin, Russia, developed both by the Russian government and by Japanese interests, is heavy, ranging in gravity from 20.7 to 21.5 deg. A.P.I. Until 1934 the greater part of the petroleum produced by the Russian government was purchased by the Japanese. In 1935, however, a new refinery built by the Soviet Government at Khabarovsk, on the Amur River, began operations; and only 280,000 bbl. of crude were sold by the Sakhalinneft to the Japanese. The Khabarovsk refinery, equipped with a cracking plant, is designed to supply the requirements of eastern Siberia.

Manchuria provides a second source of crude oil supply for Japanese refineries. At Fushun, about 25 miles east of Mukden, beds of upper Miocene oil shale, containing four to ten percent of oil, overlie thick coal seams that are being mined by a Japanese company. The experimental mining and retorting of the oil shale began in 1926 on behalf of the Japanese Navy.

A plant for refining shale oil at Fushun was completed in November, 1929. In its first year of operation, 1930, the plant produced 28,578 metric tons (200,046 bbl.) of heavy oil, 10,606 tons of crude paraffin, 13,332 tons of ammonium sulphate, and 2685 tons of coke. In 1932 there was a production of 43,275 tons (302,925 bbl.) of heavy oil, 13,897 tons of crude paraffin, and 3597 tons of ammonium sulphate. Cement is made from the shale after extraction of the oil. In 1935 a Dubbs cracking unit was installed at Fushun, giving a yield of 62 percent of gasoline. The production of gasoline for 1936 was estimated at 136,000 barrels.

Until 1934 foreign companies, chiefly the Standard-Vacuum, the Royal Dutch-Shell, and The Texas Company, controlled 80 percent of the sale of mineral oils in Manchuria. The rest of the trade was divided among the Japanese and the Russians, especially along the routes of the South Manchuria and the Chinese Eastern railways.

A law was promulgated on November 14, 1934, effective April 10, 1935, creating a government monopoly of the sale of mineral oils in Manchuria, and placing the refining, import, and export of mineral oils under government license.

A refinery with a capacity of 420,000 bbl. yearly was constructed at Kanseishi, across the Bay from Dairen, by the Manchuria Petroleum Company. Operations began in April, 1935, principally on crude petroleum imported from California. The capacity of the plant was doubled during 1935. At the end of the year the Dairen refinery and the cracking plant at Fushun was said to be meeting the total gasoline demand of Manchuria, estimated at 28,000 bbl. a month.

By the import tariff, which went into effect on November 22, 1934, "light oils" imported into Manchuria from Japan pay about one-fifth of the duty assessed against refined kerosene imported from other countries.

The Manchuria Petroleum Company also is busy prospecting for oil in Manchuria. Drilling for petroleum has begun at Dalainor and in Jehol.

For many years Japanese interests have been prospecting in British Borneo, but no commercial production has been attained. A concession in Netherland New Guinea has been granted to a Japanese company.

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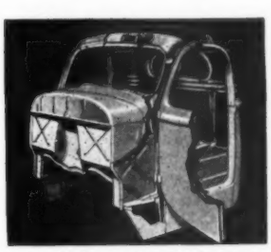

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Recent Improvements in Natural Gasoline Manufacture

Progress and trends in processing gas and in method of sampling and testing gas for gasoline content

By W. L. RIFENBERICK[1]

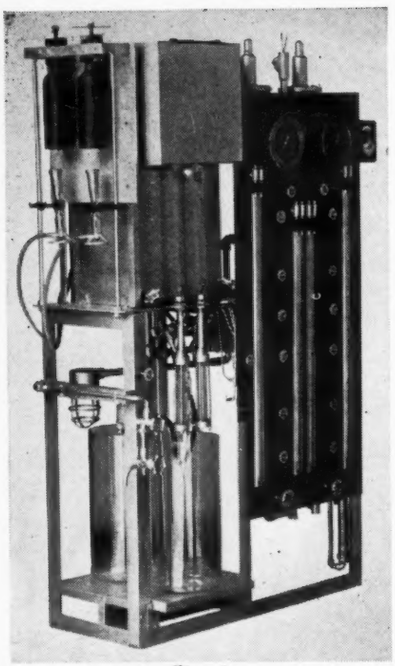


Fig. 1

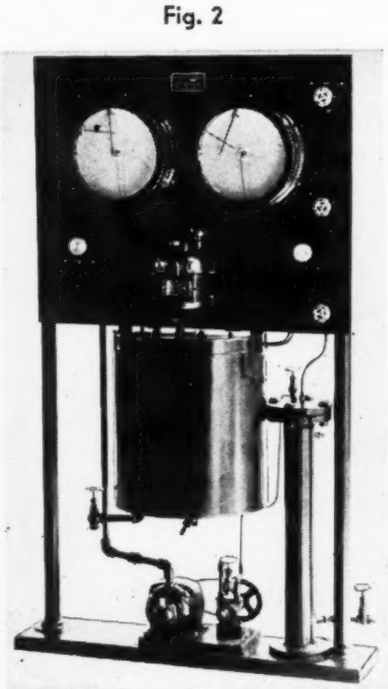
ONE of the major improvements in the gasoline industry, particularly with regard to natural gasoline, is the method of testing gas for its gasoline content. Before the California Natural Gasoline Association developed the rectified gasoline test, the tests were not comparable with plant production. The old 30-lb. 32-deg. test gave a result without regard to vapor pressure of the product, or, more correctly, without regard to a vapor pressure comparable with plant production.

Plants in some fields would make only 60 percent of theoretical production, while in others similar plants, no more efficient, would produce 80 percent. This caused criticism of the plant with the apparent low efficiency. The difficulty was due to the butane, etc., held in the condensate. Some fields have gas with a high-butane content, while others, or plants treating large quantities of recycled dry gas, will have a relatively low-butane content. The high-butane content of the gas would show a greater gasoline content; however in most instances the butane in the test sample could not all remain in the finished gasoline.

Most of the difficulties caused from the results of the old 30-lb.-32-deg. charcoal tests have been overcome with the rectified test in that the resulting gasoline in the latter test always is of the same quality. It is approximately 22-lb. vapor pressure at 100 deg. fahrenheit. The results can be corrected to a different vapor pressure by means of a set of correction factors. It is now possible to obtain a gasoline content that will be fair to all parties and make a fair distribution of gasoline in a plant having formation gas from some wells and recycled gas from others.

The rectified test is the old 30-lb. 32-deg. charcoal test insofar as the first part of it is concerned. The condensate resulting from that test is then rectified to a 22-lb. product. One is now able to get an accurate picture of the gasoline lost in the dry gas, while formerly it was impossible without resorting to the fundamental analysis test.

Fig. 2



A plant may show a dry gas content of .25 gal. with the 30-lb. 32-deg. test and only show .04 gal. with the rectified test. There again it usually was a function of the butane in the dry gas instead of the pentane plus insofar as the old test was concerned. It is believed that any gasoline plant with a reasonable degree of efficiency should not have a dry gas content of more than .04 gal. per 1000 cu. ft. when a rectified charcoal test is made.

The new method of gas-testing is almost universal in California. Fig. 1 is a front view of the apparatus used in making the distillations and rectification of the condensate.

Improvements in Gas Sampling

In the last two years the distribution of gas and gasoline in the gas has become a very important problem in Kettleman Hills. The Kettleman North Dome Association has the problem of making an equitable distribution of these two products. Since the deviation from Boyle's law has been well established for high-pressure gas in that field, the problem of gas distribution is relatively simple; however, the distribution of gasoline has not been very simple until recently. Very large sums of money are being expended on a relatively rough method of gas sampling. It is the custom to take a grab sample of gas to determine the gasoline content. Tests are made according to the rectified method. It is assumed that the gas has the same gasoline content as the grab sample until the next test is made. This is not always accurate but in most instances the only manner in which the samples can be taken.

In Kettleman Hills one company has devised a method of sampling that is accurate. The procedure is to have a large vertical gas-sample bomb. The

(Continued on Page 42)

[1]Vice-President, Industrial Engineers, Inc., Los Angeles, California.

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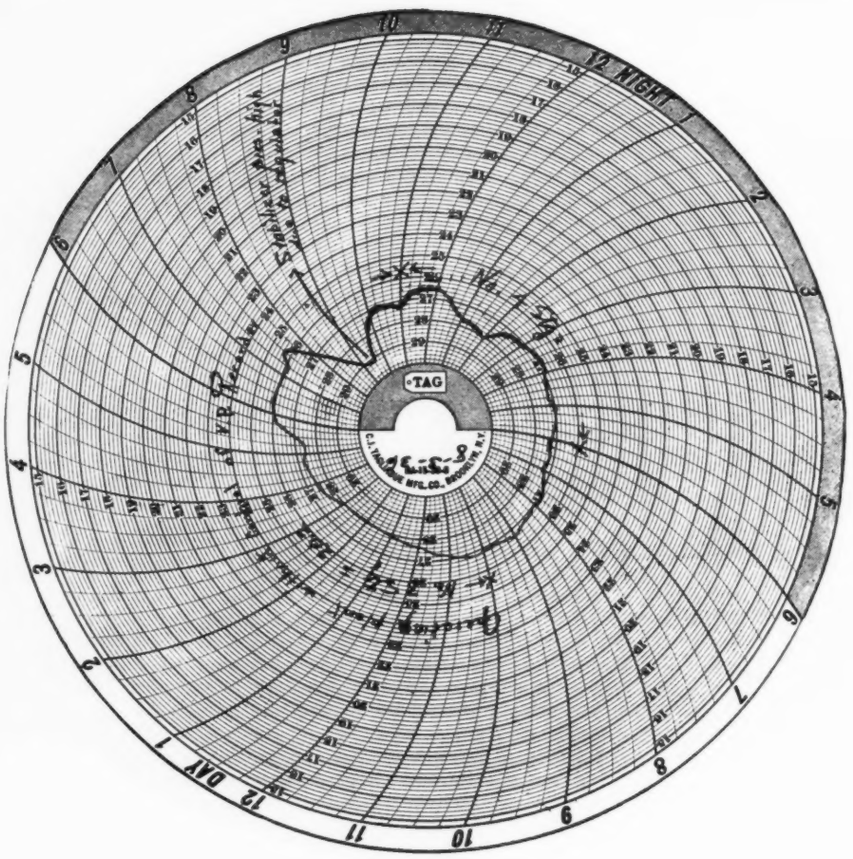

Fig. 3

(Continued from Page 38)

base is heated to prevent the formation of condensate. Suitable equipment, such as a metering device to admit gas from the 400-lb. line into the bomb, is used. Thus gas is put into the large sample container at a uniform rate throughout the 24 hours. From the sample container another sample is taken for determining gasoline content of the gas. With a 24-hour or continuous gas sample, and the rectified charcoal test, a really accurate distribution of gasoline is obtained. This procedure is used, not to distribute gasoline from individual wells, but between total gas to the plants in the Kettleman North Dome field.

Gas Sampling Containers

It appears that there is still one remaining anomaly in the distribution of gasoline. Some companies believe that erroneous results are being obtained when rusty sample bombs are used. The rust apparently has an effect of holding gasoline fractions, with the result that a lower gasoline content is obtained than with a clean bomb. A committee is now working on this problem. Simultaneous samples are being taken into a bomb well rusted on the inside and also into an aluminum bomb. A fundamental analysis will be made on the gas from each bomb to determine the effect of rust, if any. It appears that there is quite conclusive proof that rust is detrimental to accurate results.

Fractionation of Gasoline

During recent years refiners have gone to considerable expense to separate efficiently the gasoline from the crude. If as much as one percent of gasoline were left in the crude, the loss would be considerable in a large refinery. This same degree of care has not always been used in the manufacture of aviation gasoline, casinghead gasoline, etc. For example, in refractionating aviation gasoline, it is not uncommon to find a vapor pressure variation of considerably more than one lb. on hourly samples from the rectifier. The result is the loss of good gasoline into a lower price bracket during periods of high vapor pressure and likewise too high an end point is obtained when a low vapor-pressure product is produced. Equipment has been developed during the last two years that will give a continuous record of the vapor pressure of the product being produced from a rectifier. With this apparatus the production from a rectifier can be increased as well as the quality of the product improved. Fig. 2 shows a front view of a continuous vapor-pressure recorder of the refinery type. For vapor pressures of less than 20-lb. absolute it is necessary to pump the product from the apparatus. The equipment consists of a recording thermometer and pressure gauge. An explosion-proof agitation motor to stir the bath that is electrically controlled at 100 deg. fahrenheit. A heat exchanger and vapor-gasoline cup are in the 100 deg. bath. The flow to the unit is controlled through a combination filter and orifice. The liquid is discharged from the liquid-vapor cup with a float mechanism through a cooler and into the pump that delivers the gasoline sample to a container or pipe line.

The recording pressure gauge gives a continuous record of the product from the rectifier. Fig. 3 shows the record of vapor pressure from a rectifier in which the face of the recorder was blanked from view of the operators. The popular consensus formerly was that a uniform kettle temperature and column pressure would give a uniform vapor pressure. That is true with respect to the kettle temperature and pressure, but it does not necessarily follow that the vapor pressure will be constant at the reduced temperature of 100 deg. fahrenheit. This is shown in Fig. 3. The accuracy of the instrument has been well established by means of taking samples of gasoline, making fundamental analysis, and comparing the computed vapor pressure with the recorded. In many plants when using this equipment it is necessary to adjust the kettle temperature five and six times a day to produce a constant vapor-pressure product.

Uniformity of Product Into Gasoline Plant

The vapor-pressure recorder has demonstrated the necessity of having as nearly uniform feed to the absorption plant as possible. Many plants put the line drips into the distillation unit at a rate that would run them for a few hours. This produces a heavier feed to the rectifier during the running of the drips, resulting in a different vapor-pressure product from the rectifier during the drip-running period.

Fig. 4 is a chart taken from a 50-plate rectifier that gives exceptionally good results. It has been demonstrated that decidedly better results are obtained with 40 plates than 30 in a casinghead rectifier.

Recycle Plant Vapors

Refiners and operators of gasoline plants have been struggling for years

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with the problem of what to do with uncondensed vapors. The older method was to recycle them through the absorbers. Most operators are agreed that the dry gas losses are higher when the plant vapors are recycled than when they are disposed of through the rectifier. The other method to dispose of the bulk of the undesirable light fractions absorbed in the lean oil is to fractionate the fat oil until the overhead from the fat-oil rectifier does not contain pentane.

Problem of Used Equipment

Many, in fact, most plants are confronted with the problem of what to do with their used equipment. Much of it is of little value. This is true of absorbers, stills, etc. Many operators are having new, efficient trays installed in the old shells.

Rectification Liquid and Plant Vapors

One independent refiner who has a great deal of used and obsolete equipment has been very successful in having it rebuilt and also has worked out a system of using low-pressure vessels where otherwise high-pressure ones would be required. This refiner has a casinghead plant adjoining his refinery. He also has a vapor-recovery system in the refinery.

It was desired to rectify the casinghead gasoline, the straight-run motor fuel, and eliminate the recycling of uncondensed vapors from the absorption plant, as well as the refinery and tank farm vapors. The flow sheet shown in Fig. 5 was worked out by this refiner to accomplish the desired results. The problem is difficult because of the large amount of carbon dioxide accumulated in the plant vapors. It comes from the wet gas that contains a large percentage of carbon dioxide. All the vapors are collected and compressed with the low-pressure compressor cylinder and discharged into the rectifier along with the treated tops and casinghead. The column pressure is only 65 pounds. A reflux cannot be produced with but 70-deg. cooling water and 65-lb. pressure. The overhead from the column is compressed in the high-pressure cylinder. The pressure is then 250 lb., which is sufficient to produce a reflux with 70-deg. cooling water. An accumulator is on the condenser outlet. The uncondensed vapors are discharged from the accumulator to the dry line and the liquid is returned to the top of the rectifier as a reflux. The top temperature varies considerably, depending upon the composition of the overhead. The top temperature ordinarily is more than 32 deg., but trouble never has been experienced with temperatures as low as 20 degrees. This low temperature never has been maintained for more than a day or two.

The result of all this is that a vastly superior motor fuel is produced. It is free of the undesirable light ends. The losses from the overhead dry gas is negligible. The N-butane loss in the overhead is only 15 to 18 gal. a day. The object is to retain all the N-butane in the finished gasoline and discard the iso-butane from the finished product.

The feed to the rectifier varies materially, depending upon the quality of finished product desired. The treated tops fed to the column will vary from 30,000 to 40,000 gal. a day and the casinghead gasoline may vary from 10,000 to 20,000 gal. a day. The uncondensed plant vapors fed to the column will total approximately 200,000 cu. ft. a day with a discard of 160,000 to 170,000 cu. ft. daily. The finished motor fuel averages approximately 50,000 gal. a day. The quality of the product has been improved and the production has been increased 400 to 500 gal. a day over the discard from treated tops. The motor fuel varies from 8½-lb. to 11½-lb. Reid vapor pressure, depending upon climatic conditions. It also has an anti-knock value of more than 71.

The gasoline content of the waste gas from the rectifier, shown in Table 1, is decidedly lower than was being obtained at that time in the dry gas from the absorption plant; so a gain in production had to be made, except for the loss in the treated tops. There was a net gain in the process.

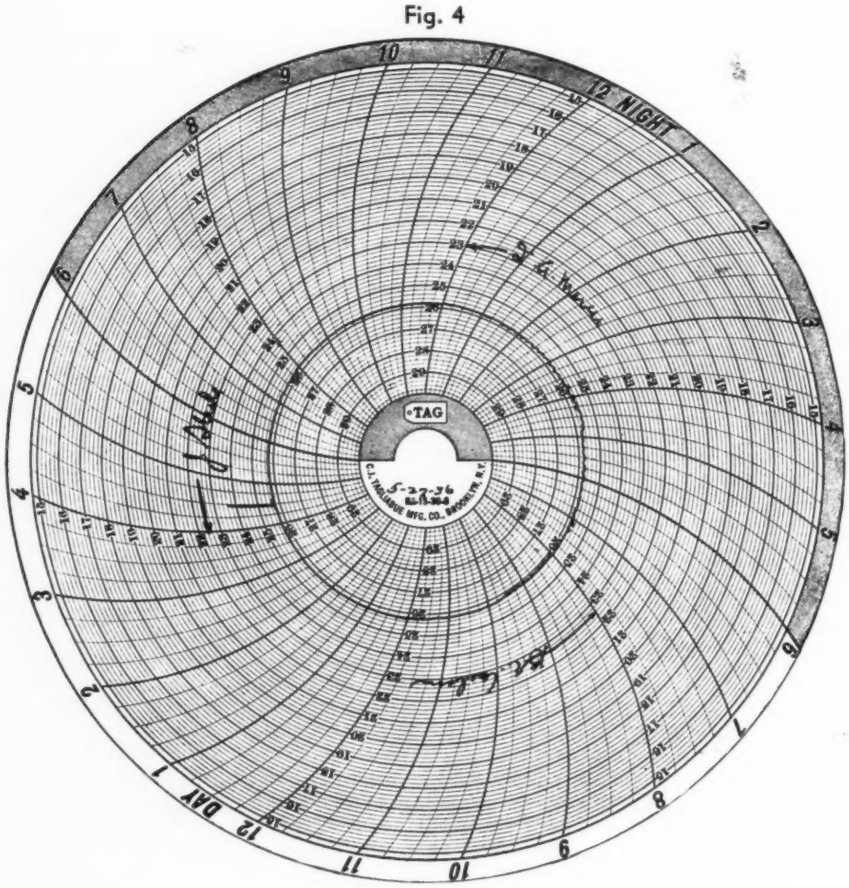
This company since has put in a similar unit in another of their gasoline plants to produce butane and pentane from their carbide rectifier and from the plant vapors that formerly were recycled. The flow sheet is comparable to that shown in Fig. 5.

Table 1 gives the fundamental analysis of the products from the rectifier.

The raw products all are deficient in N-butane. Even the natural gasoline has very little butane, therefore, in order to produce a motor fuel with vapor pressure high enough to meet conditions in cold weather, during which the tests were made, the results of which are shown in Table 1, it was necessary to retain a part of the iso-butane. During warmer weather it is eliminated with nothing lighter than N-butane remaining.

The composition of the tops to the

Fig. 4



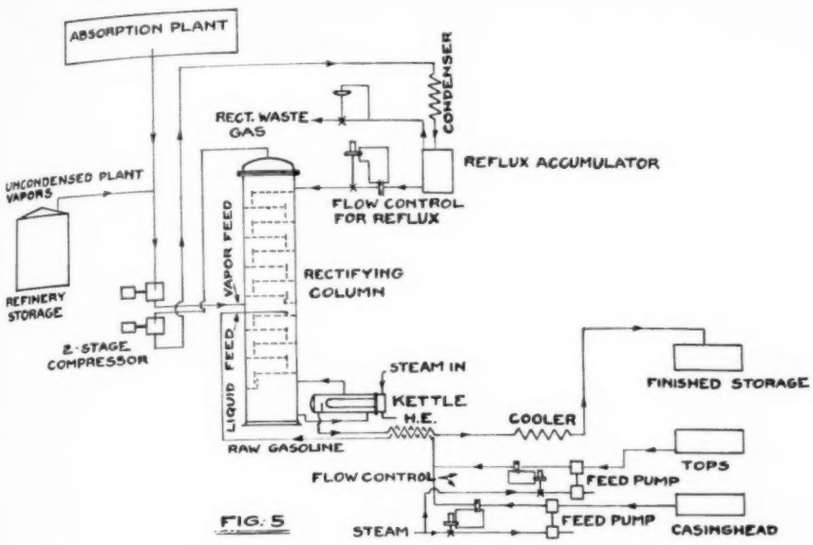


FIG. 5

TABLE I

	Tops to Rectifier[1]	*Finished Gasoline*[1]	*Rectifier Waste Gas*
Air	—	—	3.5
Carbon dioxide	—	—	25.9
Methane	—	—	32.16
Ethane	trace	—	7.02 G/M
Propane	1.42	—	25.28
Iso-butane	0.82	1.26	5.81 1.89
N-butane	3.03	7.36	0.33 .10
Iso-pentane plus	94.73	91.38	—
	100.00	100.00	100.00

[1]Liquid volume.

rectifier is significant in that they contain 1.42 percent propane. Refiners are becoming convinced that rectification of straight-run motor fuel is very essential. In fact, all products entering into the finished gasoline should be fractionated to produce a gasoline of the desired characteristics. This is becoming more important since the modern automobiles are so closed in around the engine.

Aviation Gasoline

Rapid advances have been made in the design of automobile motors. In fact, the average automobile is better than the racing cars of years past. Compression ratios have increased rapidly. They can increase no faster than the refiner can supply a suitable gasoline at a reasonable price, however. The demand for higher octane gasoline has been heavy. Were it not for the cracking process, Ethyl, and polymerization, it would not be possible to have the small snappy engines of today. Neither would it be possible for airplanes to make the speeds they do.

Present-day airplane speeds are possible because the engine manufacturers can design the motors with a higher compression ratio when they have 100-octane gasoline than they can with 90. The result is that a motor of a given hp. is smaller when designed for 100-octane gasoline than 90. This means the smaller engine has less wind resistance than do larger ones. It also means that the one with less wind resistance can fly at a greater speed.

The cost of producing 100-octane gasoline still is too high for commercial transport lines but it is not for the army and navy where performance is paramount to cost of fuel.

Transport ships have discontinued the use of a gasoline with one octane for flying and another for taking off. They now use only the higher-octane gasoline.

We do not know where the problem of getting a higher octane gasoline will lead us, but the constant demand by the public for a better performing car and better gasoline mileage is causing the car manufacturer to build a motor with higher compression ratio. As previously stated, the motor manufacturer cannot build a motor for which there is not a suitable fuel. This will force the refiner to produce a higher-octane gasoline, but it must be done at a price the public can pay.

Safety in Plants

Gasoline plant owners have spent considerable money during the last year to make gasoline plant storage safer in event of fires and earthquakes. Either can destroy a complete plant. If the piping on casinghead storage tanks breaks during an earthquake a serious explosion or fire almost is certain to be the result. If the tanks are protected properly, they will not explode in case of a fire around them. It is hard to imagine anything worse than an exploding storage tank. Such a thing is entirely unnecessary today with the knowledge we have of protecting the tanks.

Consumption of Liquefied Petroleum Gases Increasing

MORE than 106,000,000 gal. of liquefied petroleum gases were consumed for domestic and industrial purposes in 1936, indicating the rapidity with which this new group of products has grown in favor. Seven years ago the national consumption was only about 18,000,000 gal. These gases, which include propane, butane, pentane, and propane-butane mixtures, are obtained from natural gas in the process of producing natural gasoline, and also from refinery gases. They are composed of hydrocarbons similar to those predominating in gasoline, their high volatility and heat value making them ideal fuels for various purposes.

In 1936 industries consumed 54,585,000 gal., more than half of which was butane. Liquefied petroleum gases also were used as raw material in the production of alcohol, acetone, solvents, anti-freeze preparations, and other chemical products. In suburban homes liquefied petroleum gases, commonly known as "bottled gas," extensively are used. In 1936 home-owners consumed more than 30,000,000 gal., about 80 percent being propane.

Gas companies consumed 9,371,000 gal. in 1936, two-thirds being butane, which was mixed with manufactured gas. Utilization of liquefied petroleum gases as fuel for internal-combustion engines increased consumption by 12,476,000 gal. last year, three-fourths of this quantity representing butane. Miscellaneous uses accounted for the consumption of 206,000 gallons.

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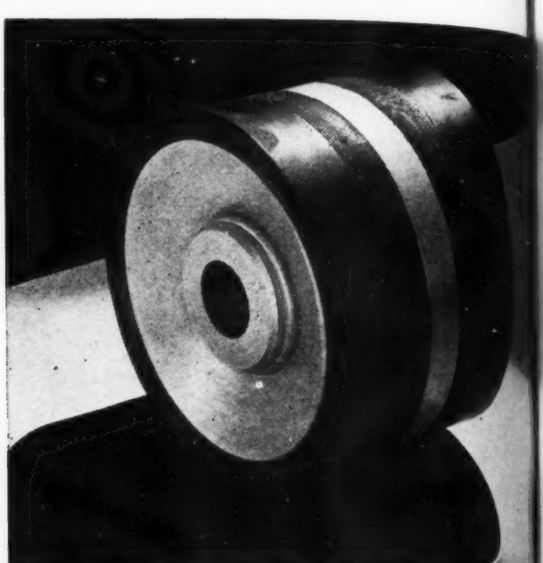

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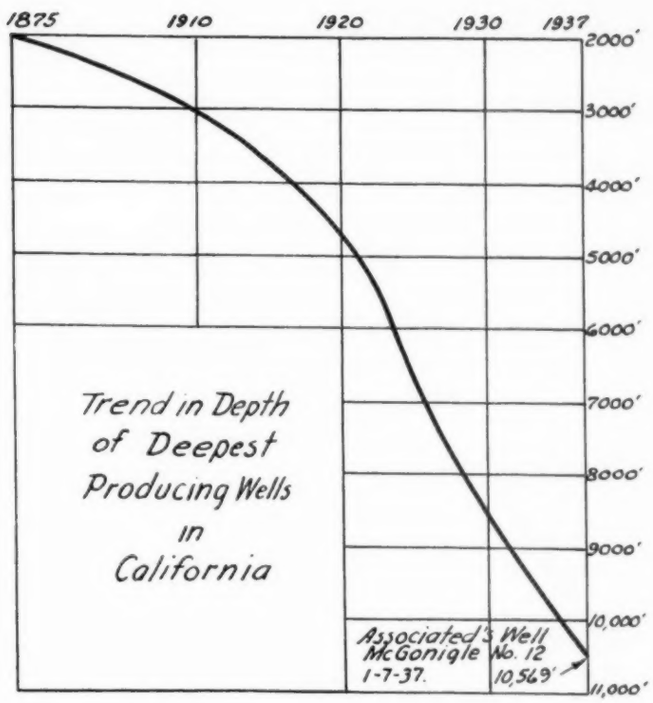
Fig. 1. This curve was plotted by setting off the depth of each deepest well at the time of its completion. Only wells with commercial production were used



By

WALLACE A. SAWDON,

Petroleum Engineer, Los Angeles

Equipment and methods keep pace with requirements that change rapidly with advancements of the industry

Developments in Drilling and Production on Practices in California

THE past year again has indicated that greater producing depths will have to be considered in the realm of probability and that methods and equipment for drilling those depths and for producing them efficiently after they are drilled still must go through the stages of development and perfection that have accompanied oil field operations in the past. New fields of what are now considered comparatively shallow depths, however, will be discovered and developed; and increased efficiency in their drilling and production necessarily must be carried on. There is, however, a factor that is facilitating the application of new methods and equipment; this is the attitude of drillers and field men toward innovations. Their spirit of coöperation concedes that drilling and production have become scientific operations and they are willing to apply the engineering principles of procedure and design that constantly are being evolved without the prejudice of precedent so prevalent a few years ago.

The trend of deep commercial production in California is indicated in Fig. 1. Yet the deepest well in the state (completed only a few months ago) no longer holds the world record. It seems impossible that the trend, as indicated by an accompanying curve, could continue for much longer without flattening out; however, the deepest test in the state since has been drilled to 12,618 ft.—a depth but little short of the world's drilling record. This was Superior Oil Company's No. 8 KCL about eight miles southwest of Bakersfield, which was plugged back after the drill pipe stuck. Production at such a depth within the next ten years would merely follow the depth trend as now indicated.

Of more importance than depth, however, is the discovery of new fields.

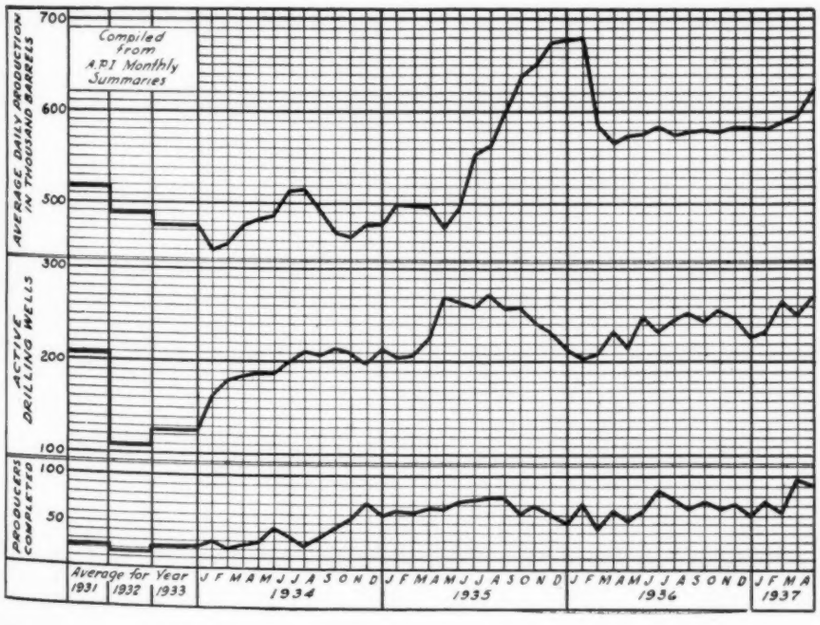
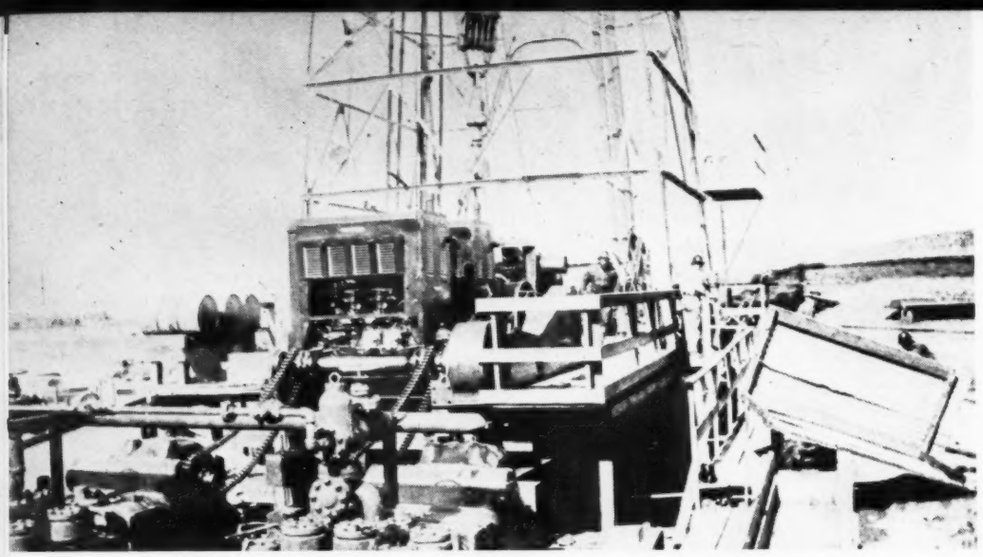


Fig. 2. Chart showing production, drilling activity, and completed wells in California



Left—A dual butane-engine installation was used to drill this well to 7000 feet. The engines are of 250 horsepower. The forward engine drives the drawworks. The rear engine shown powering the mud pumps can be compounded with the forward engine to provide double hoisting capacity. (Photo courtesy Tide Water Associated Oil Company)

The latest intensive development in California is the Wilmington area. The productive limits of this field are not known but actual production at the end of May already had reached nearly 40,000 bbl. daily. The potential probably is more than twice that amount. Pipe lines have not been run into the field as yet and there is no present prospect that such facilities will be immediately available. The oil from the field is coming from depths of less than 4000 ft., its gravity ranges from 17 to 25 deg. A.P.I., and its sulphur content is comparatively high.

Production from California has been increasing gradually, the average daily production now being more than 600,000 barrels. This is shown in Fig 2, as is also the increase in drilling activity. The oil produced in the state during the past year, however, evidently has not been offset by the discovery of new production to an amount sufficient to maintain the proved reserve. The total reserve in June, 1936, was estimated at a little more than 3,000,000,000 bbl., while the A.P.I. estimates as of January, 1937, gives the state a known reserve of only 2,956,000,000 barrels.

Prospecting in the state, of course, is being carried on extensively and geophysical exploration is being employed to advantage. With new areas necessary to maintain the present reserve, it is felt that geophysical prospecting will become an increasingly important factor in the oil industry.

A flowing well at Wilmington showing the foundations used for drilling rigs

Equipment Design and Application

A recent development in California has been the adaptation of butane as a fuel for prime movers in rotary drilling. Although butane has been used as motor fuel for trucks and tractors for at least five years, it is only during the past year that it has been employed on drilling operations. In this short time, however, probably as many as 30 butane-powered rigs have been put into service in the various fields all over the state and, while gas engines generally have been converted for use of this fuel, there seems to be a possibility that engines especially designed for butane operation will find favor where conditions warrant their installation. Their application, moreover, includes the completely portable outfits for shallow drilling, as well as the heavier installations for deeper wells.

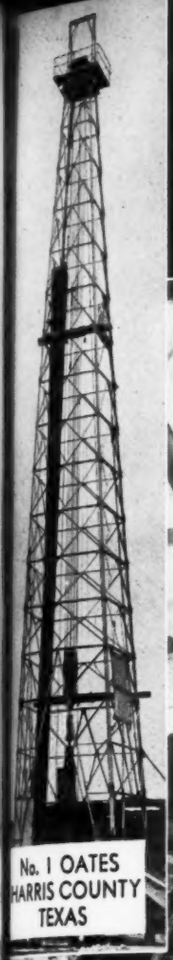
In a discussion on the subject,[1] L. R. Smith has given three general types of butane engine installations. Type 1 consists of one engine coupled directly to the drawworks with a second engine driving the mud pumps. Type 2 is a dual engine installation so arranged that the engine regularly used on the mud pumps can be compounded with the drawworks engine to provide double hoisting capacity. Type 3 is a d-c. electric outfit with either one or two engines driving the generator.

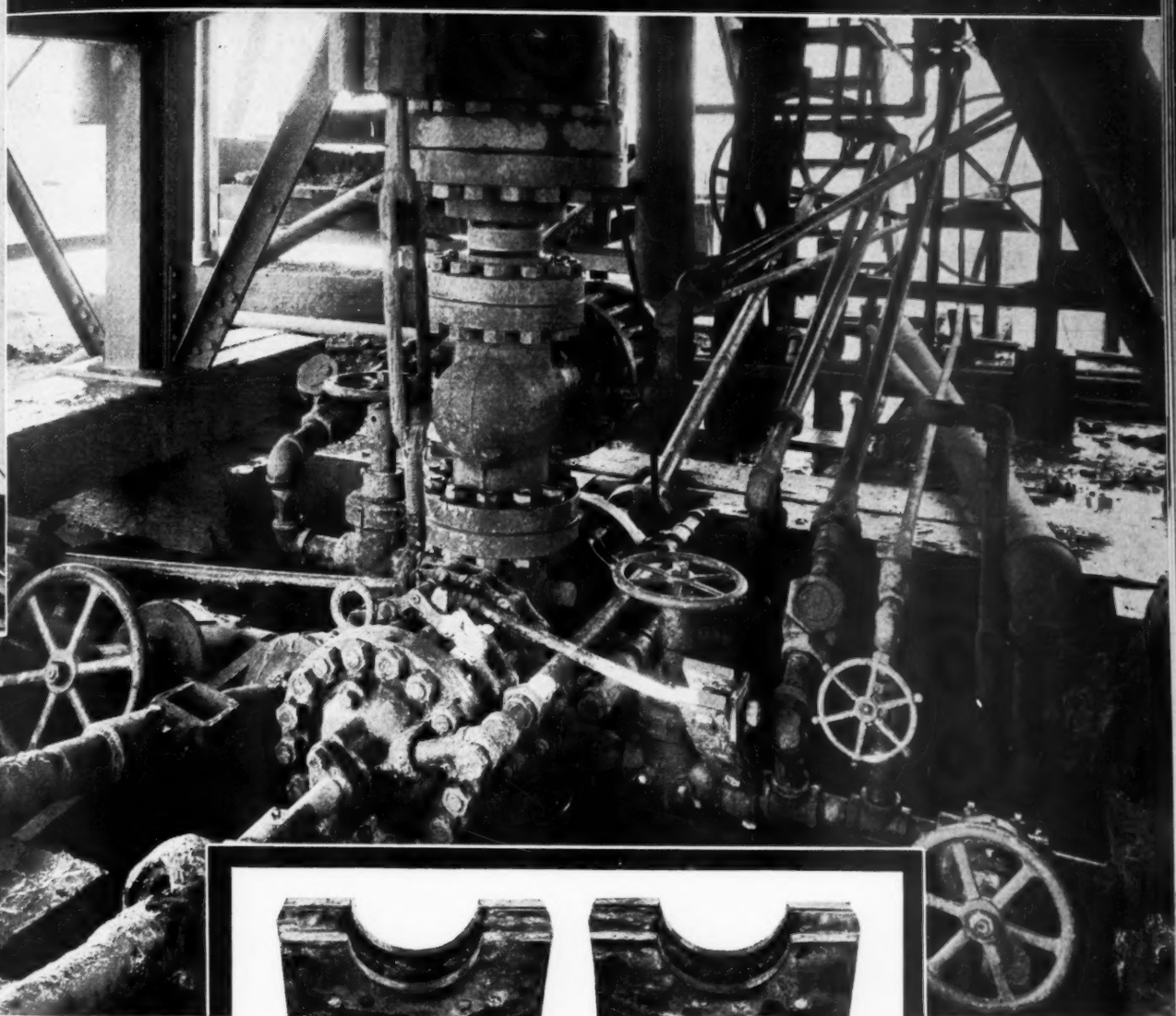
The butane for drilling operations is kept at the rig in tanks that usually consist of two with a capacity of 1750 gal. each. The tanks are portable units and are hauled to the field to replace empty ones as their contents are consumed. Butane, of course, is in liquid form in the tank. It remains liquid at 10 deg. fahr. at atmospheric pressure but at 100 deg. fahr. it has a pressure of above 70 lb. per sq. inch. With the pressure reduced it vaporizes and is mixed easily with the air necessary for combustion.

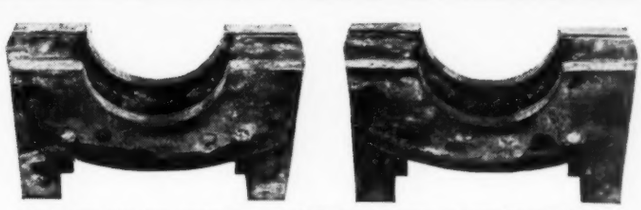
Commercial butane of the kind used for drilling consists of from 5 to 20 percent propane and from 75 to 80 percent butane. In this form it is considered a most economical fuel

[1] "Butane Engine Drilling," by L. R. Smith, Tide Water Associated Oil Company, Pacific Coast Section, A.I.M.E. meeting.

3½" OD DRILL PIPE UNDER PRESSU[illegible] EIGHT HOURS AS 2900 POUNDS THROUGH CAMERON 7" TYPE SDA PREVENTER







These are the two packers that withstood 8 hours of terrific punishment on No. 1 Oates. Despite wear, each packer held 2900 pounds well pressure at the end of the period of rotation.

CONVINCING evidence of the ability of Cameron Self-feeding Ram Packing Elements to absorb terrific punishment due to movement of drill pipe through the closed rams was provided recently on No. 1 Oates, Harris County, Texas.

At approximately 8700 feet, abnormal bottom hole pressures, estimated to be more than 7000 pounds, developed in the 700 feet of open hole below the 8000-foot oil string. Circulating fluid weighing 17½ pounds proved barely sufficient to hold well pressure when in good condition, and insufficient when cut by salt water which intruded.

In an effort to prevent sticking the 3½" O.D. drill stem, pipe was rotated continuously through the closed rams of the 7"-5000 pounds test Cameron Pressure Operated Blowout Preventer for a period of eight hours. For six hours, 400 pounds fluid closing pressure was maintained behind the rams of the Cameron Type SDA Preventer. As surface pressure continued to build up, once as high as 2900 pounds, it was necessary, during the last two hours, to apply 800 pounds fluid closing pressure.

Inasmuch as there was no means of repacking the one Cameron Type SDA Preventer on the well, it was deemed inadvisable to continue pipe rotation after eight hours. As shown above by the unretouched photograph of the two worn Cameron Self-feeding Ram Packing Elements, which held perfectly at the end of the period, the resilient packing in these elements positively does feed out as required. Further, their capacity to withstand the wear and tear imposed by eight hours of pipe rotation under pressure clearly reveals why they effect an immediate and positive seal when closed under normal conditions.

Operators interested in obtaining the most dependable control equipment possible should, by all means, give full consideration to the correct type of Cameron control unit or hook-up to meet their requirements.

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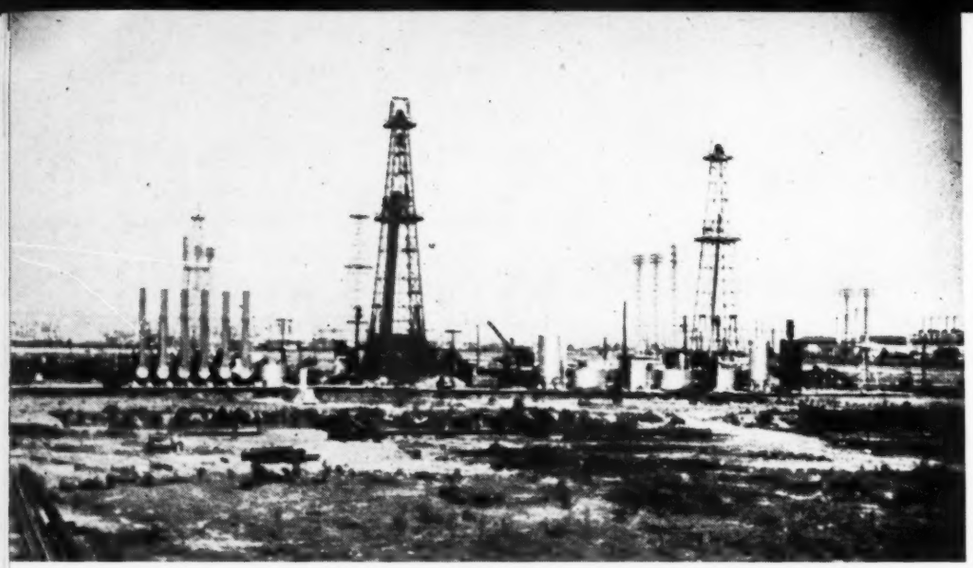
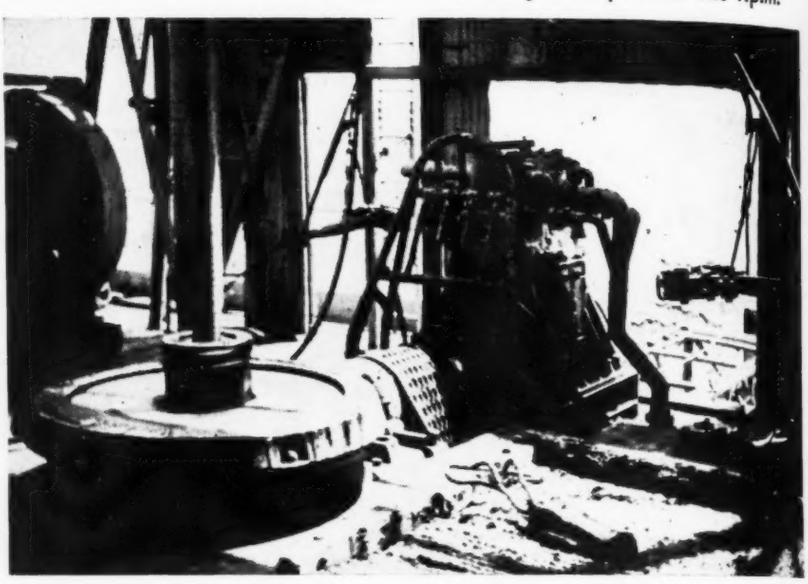


Right—Drilling wells at the east end of present development, Wilmington field, California

Below — A steam-powered direct rotary table drive in El Segundo field, California. In this installation the engine is across the table from the drawworks. The drawworks seen on the left is a standby unit. The table is rotating at a speed of 125 r.p.m.



and, since it is used in an engine as a true gas, it provides uniform distribution of fuel to all cylinders, deposits no wet fuel on the walls of manifold and cylinders, eliminates crankcase dilution, forms no carbon and gives practically complete combustion. It is transported as a liquid but used as a gas. Interesting data on its economy are given by Mr. Smith in his paper.

The Type 1 installation, when consisting of a 125-hp., 1800-r.p.m. engine on the drawworks and a 150-hp., 900-r.p.m. engine on the mud pump probably will be found satisfactory for drilling up to 2500 or 3000 feet. The Type 2 installation may be made up with two 150-hp. engines but for deeper drilling up to 7000 or 8000 ft., the two engines should be 250 hp., 1800 r.p.m. or of similar rating. In an accompanying illustration, the rig shown was one of the early ones used and consists of two 250-hp. engines. The well being drilled was completed at about 7000 ft. and the butane consumption was 16 gal. per hour for the entire outfit.

There have been but few butane-driven a-c. electric generator units used to date. This type installation, however, is adaptable to drilling to extreme depths and naturally is comparable to other types of a-c. generator units.

Transportation of the dual engine installation is facilitated by making the drawworks and engines up in four units. These units each can be handled by a truck and readily are assembled when rigging up. The engines themselves, of course, are similar to gasoline engines of the same rating but designed for butane carburetion and with a different compression ratio.

The use of rotary table drives has gained considerable headway in California during the year and indications are that the advantages offered by the individual power for rotating may make the rotary table drive more general in application. Both electric and steam types now are being used, and both seem to offer economies as well as to provide better facilities for drilling control.

One of the disadvantages of high-rotating speed has been the wear and tear on surface equipment, especially on chains. As there is a tendency toward increasing rotating speed, separation of hoisting and rotating power may do much toward the developmen of a more efficient technique with high speed. Economy, of course, must be given due consideration; but from present data it appears the direct rotary drive provides economies in addition to saving on maintenance and replacements of chains and other surface equipment.

Comparative results procured with rotary table drives and with the conventional method of chain drive from the one engine powering both the drawworks and table have been presented for electric rigs by C. F. Forsberg.[2] While test curves plotted in this paper to indicate the results compared the use of 11-in. bits rotated by direct table drive with 12¼-in. and 14¾-in. bits rotated by conventional drive, the hp. output at any given rotating speed under a given weight evidently was lower for the direct drive than for the conventional drive. Moreover, where there was zero load on the bit, there was found to be a difference of about eight hp. between the direct drive and the conventional drive at the same rating speed. This probably could be expected, as the friction caused by chains and bearings neces-

[2] "Rotary Table Drive," by C. F. Forsberg, Honolulu Oil Corporation, Spring Meeting Pacific Coast District, A.P.I., Los Angeles, California, April 13, 1937.

Rotary Drive	Time to Drill	Angle of Variation		Number of Bits Used
		Maximum	Minimum	
Conventional . . .	7.0 days	1.5 deg.	1.5 deg.	16
Conventional . . .	5.6 days	2.5 deg.	1.75 deg.	15
Direct	4.33 days	1.0 deg.	0.75 deg.	13

(From "Rotary Table Drive," by C. F. Forsberg, Honolulu Oil Corporation, Spring Meeting of Pacific Coast District, A.P.I., Los Angeles, April 13, 1937.)

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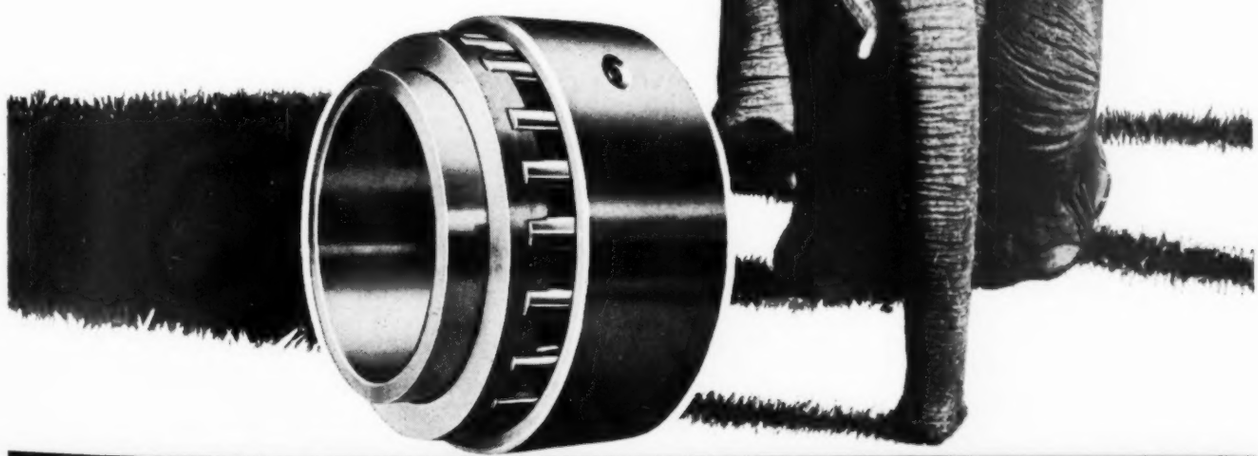
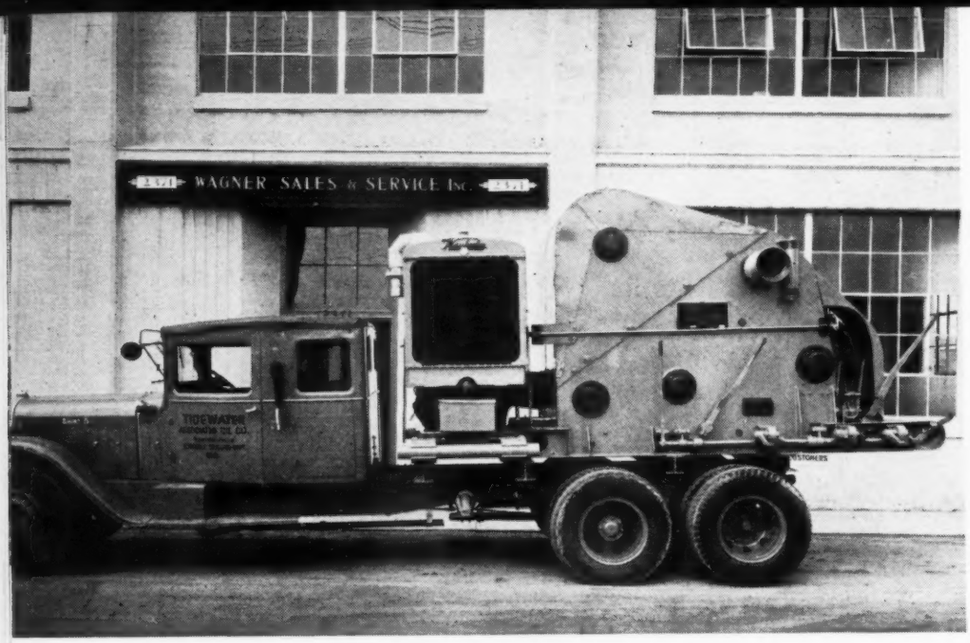


AMERICAN *HEAVY DUTY* *ROLLER BEARINGS*



A portable drawworks unitized with butane engine drive

sary on the conventional drive is eliminated by directly connecting the table to an engine used exclusively for its rotation.

A further comparison of results procured by the direct table drive and the conventional drive was made for wells drilled in the same vicinity. All these wells, as tabulated below, were drilled to 3100 ft. with the same size and type of bit. Although no tests for power output were made in these operations, the physical data obtained indicate an advantage in driving the rotary table with its own power.

While the above covers only electric-powered direct-rotary drive, the economies provided by the steam-driven type can be assumed to be comparable. Drillers using the steam-powered engine claim a saving in steam consumption that also can be added to the elimination of upkeep of the rotary chain connecting the countershaft to the table, and the maintenance of other equipment that may be adversely affected. This applies particularly where high rotating speeds are used. Rotating speeds of 150 r.p.m. and above are becoming quite general in California and one company has used speeds of 250 to 300 r.p.m. satisfactorily. With the direct-rotary drive, a speed of 500 r.p.m. may be tried without tearing up other equipment as might happen if the power had to be supplied through a chain from the countershaft. Whether such speed under certain conditions may be advantageous is yet to be determined.

In practically all installations of direct-rotary drive, the engine is placed to the side of the rig in the position occupied by the sprocket on the conventional drive. In at least one instance, it was placed across the table from the drawworks but it is doubtful if this is of any advantage. The one shown in an accompanying photograph happens to be so located but this is an exception rather than the rule. Moreover, by placing the direct drive to the side, a sprocket can be employed and a chain used from the countershaft if the necessity arises. Where conditions make it desirable to have the pipe rack on the side of the rig usually occupied by the table drive, the direct-rotary drive, of course, can be placed where most convenient.

Wire-line coring, while introduced into California operations some years ago, has become more generally used during the past year. This increased application probably has been due to a number of causes, not the least of which is that drillers have become familiar with their use and have learned to operate this type of coring equipment more efficiently. There is, however, a greater amount of suitable drill pipe for accommodation of the tool, and surface equipment has been made available for its operation. Most rigs in California now have sand reels, placed on the main drawworks or set behind the engine of the auxiliary drawworks; but portable hoists and independently-powered sand reels also have been used for wire-line coring when necessary.

The recovery obtained with wire-line coring equipment also has increased and now can be expected to run as high as from 85 per cent up. This factor, and the ability under various conditions to make continuous runs of from 100 to 200 ft. before pulling the drill pipe have demonstrated the effectiveness and economy of the device.[3]

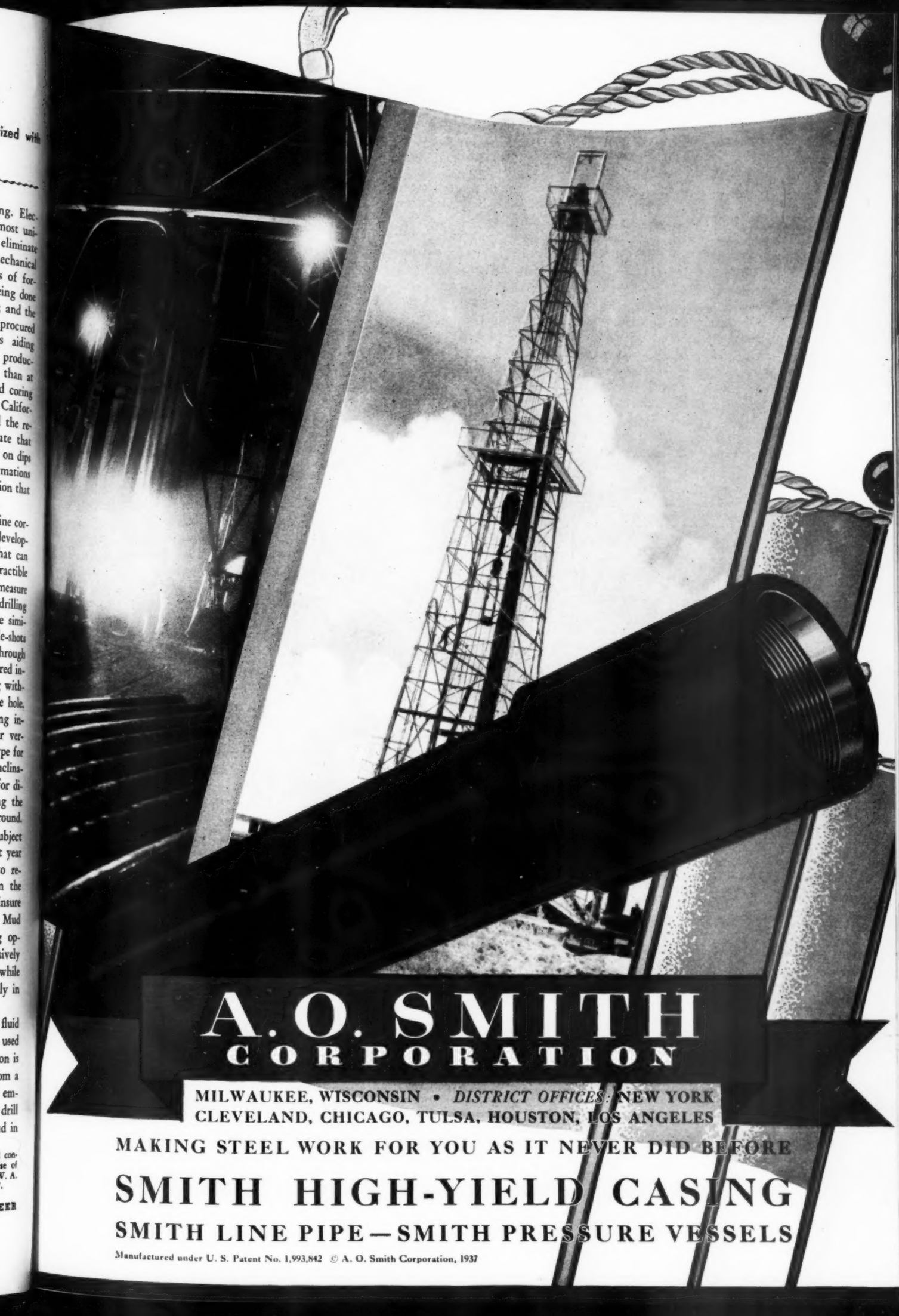
Wire-line coring has not superseded the conventional type of rotary core barrel and has not eliminated the desirability of electrical logging. Electrical logging has become almost universal in practice but does not eliminate the necessity for taking mechanical cores. Paleontological analysis of formation samples probably is being done to a greater extent than ever; and the study of subsurface data procured from all sources possible is aiding greatly in making drilling and production operations more efficient than at any time in the past. Oriented coring also has come into vogue in California during recent months and the results already obtained indicate that this method of procuring data on dips and strikes of subsurface formations may provide valuable information that otherwise cannot be obtained.

A natural outcome of wire-line coring operations has been the development of survey instruments that can be run by means of the retractible wire-line coring equipment to measure the angle and direction of drilling wells. Such instruments operate similarly to the regular sized single-shots but are small enough to run through drill pipe to get readings at desired intervals during drilling or coring without pulling the tools out of the hole. Small instruments for measuring inclination only may be used for vertical wells but the single-shot type for measuring both direction and inclination supply the necessary data for directional drilling or for plotting the entire course of the well below ground.

The mud problem has been subject to further study during the past year with especial attention given to removal of the mud sheath from the face of the sand in order to insure free access of oil into the hole. Mud conditioning throughout drilling operations is being done more extensively and the use of the proper mud while drilling-in is felt to aid materially in well completions.

The use of oil as a circulating fluid for well completions has been used successfully, both where production is from a low-pressure zone and from a high-pressure zone. The method employed in low-pressure zones is to drill through with a light colloidal mud in

[3]A comparison of costs of wire-line and conventional coring has been treated in "Use of Wire-Line Core Barrels in California," by W. A. Clark, *The Petroleum Engineer*, May, 1937.



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order to plaster the sand with a thin, effective sheath and protect it from water infiltration. When the total depth is reached, the mud fluid in the hole is replaced with oil before the tools are pulled out. A wall scraper is then run in, with oil serving as the circulating fluid, and the mud plaster scraped off.

When production is from high-pressure zones in wells drilled by the controlled-pressure drilling method, the oil is used as a circulating fluid while drilling through the productive zone. In following this practice, production tests are made at any time desired and the oil and gas studied both for physical characteristics and volume. Several wells have been completed during the year at Kettleman Hills and Ventura, as described in detail in a previous issue.[4]

Production

While no startling new designs of rodless pumping equipment have been introduced during the past year, the installation of rodless pumps has aided materially in the pumping of deep wells that have ceased to flow naturally or where gas-lift application or continuance has not been practical or desirable. In the case of the hydraulic-type pump, large volumes of oil are being handled by using two surface units instead of one, with the size of the units dependent upon the producing conditions encountered. Both the hydraulic and plunger-lift types of pumps are adapted to other than great depths, however, and installations have been made in various fields throughout the state.

A matter given considerable attention is that of increasing the production of wells. Upper sands previously cased off are being tapped in several fields, particularly at Long Beach and Santa Fe Springs, a considerable increase to the production of the fields thus resulting. The electrical method of locating potential productive zones behind casing is not new within the year but its use for the purpose of locating passed-up sands has increased materially. All information available from old core records, drillers' logs, or electrical coring, of course, are utilized but even when data are fairly conclusive, the electrical method of finding formations behind casing usually is employed.

In the majority of cases, the return to upper-cased sands involves plugging back. Actual penetration into the sand is then done by perforating the casing and any cement behind it and then testing the production.

Increasing production from a sand being actively produced is another matter that has been receiving increased attention. The general methods of redrilling and physical cleansing have been followed but the use of a chemical treatment to remove mud, scale, or paraffin from the face of a sand or clogged perforation is a more recent development. Chemicals have been employed to some extent for this purpose for some time but during the past year chemical clean-out work has appeared to be more successful.

To consider chemical treatment as a solution for every condition is far from advisable. In the first place, the oil has to be available in the sand. The selection of the proper chemical and the proper use of the reagent selected is most essential, as not only failure but actual harm may be done by the wrong chemical or the misapplication of the right one. In a paper recently delivered on this subject,[5] the general nature of substances employed for chemical clean-out of mud sheaths was given as follows:

Acid Reagent: Strong inorganic acids (with or without wetting agent). Semi-neutral electrolytes (with or without organic solvents).

Neutral Reagent: Aqueous dispersion of solvents (with wetting agent). Soda ash and caustic plus acid (with heat and carbon dioxide evolution).

Alkaline Reagent: Strong caustic compounds plus water (with or without heat evolution).

The scale deposited in oil wells in California usually is calcium carbonate, which dissolves in the inorganic acids with the evolution of CO_2. Acid treatments generally have employed muriatic acid for removal of this scale as chloride salts have a high degree of solubility and this acid is not as dangerous to handle as some others. To minimize corrosion of casing, tubing, and pump equipment it is desirable to employ an inhibitor with the acid in washing operations. Usually a wetting agent also is necessary to procure penetration of the acid into the carbonate material.

For removal of paraffin or asphaltic deposits, liquefaction by solvent action or the application of a heat-generating caustic chemical is reported to be most effective.

Portable hoists have been used for years on well servicing work and on repair jobs. Recently, however, such hoists have been equipped with masts to facilitate and speed up their operations, as well as to make them adaptable for wells not equipped with production derricks. The heavier types of such machines also have been equipped with rotary drilling attachments that permit a greater scope on repair work. Many of these hoists virtually are portable drawworks designed for shallow drilling and frequently are built with collapsible derricks. Their adaptation for redrilling operations and similar work requiring rotary is increasing their use for production maintenance.

[4] "Completing Rotary Wells with Oil," *The Petroleum Engineer*, October, 1936.

[5] "Chemical Clean-Out of Oil Wells in California," by M. W. Morris, Standard Oil Company of California, Pacific Coast District, A.P.I. Spring Meeting, Los Angeles, California, April 13, 1937.

Steam-operated direct rotary table drive, El Segundo, California

Northern National Gas Company's Clifton, Kansas, compressor station. Equipment consists of nine 1000-hp. double-acting, twin-tandem, direct-connected compressor units

Trends in Design, Maintenance, and Operation of Compressor Stations

By B. L. ROGERS[1] and O. H. MOORE[2]

New types of equipment have been developed, and refinements made to the older types, to keep pace with modern demands upon compressor stations

THE availability of gas from enormous reserves in various parts of the North American Continent, in the last 20 years has brought about vast extension of existing pipe-line systems that are continually being expanded, particularly since the darker years of depression are past, according to a well-planned yearly program. In addition, new pipe-line systems have been conceived on a gigantic scale.

This progress has been made possible by improved quality, rate of production, and sizes of high-pressure steel pipe available, as well as by improved machinery for transporting, laying, testing, protecting, and maintaining pipe lines.

The expansion of markets along existing pipe-line systems has been aided materially by the comprehensive advertising program of the American Gas Association, bringing to the minds of the public everywhere the desirability, convenience, efficiency, and the beauty of modern appliances.

In planning a yearly expansion program covering a number of years effort is made, insofar as possible, to select industrial markets with an eye to controlling the load factor. Despite this effort to fill the summer valley in the domestic load and favor domestic consumers rather than industrial users, a wide variation occurs at times over a period in the load factor on most systems. This is the chief reason why little change is noted in the type of equipment generally used in compressor stations for boosting gas to the required pressure at such points as found necessary on the transmission system.

The large-bore, long-stroke, double-acting, 4-cycle, twin-tandem gas engine has not changed greatly, except for innumerable refinements in details. Being of the slow-speed type it is massive, expensive to install, and cumbersome to transport, but dependable over long periods of operation.

The refinements include:

(1) Wide-range, constant-speed governors that permit a definite setting at any required speed down to 60 percent of rated speed and maintain this reduced speed. The unloading provisions now made on compressors take care of overloads, thus permitting much flexibility in adjusting to the variation in load factor and the consequent change in ratio of compression.

(2) Jump-spark ignition with distributor points adjustable while in operation, and low-tension wiring ex-

[1]Superintendent Compressor Stations, Lone Star Gas Company.

[2]Assistant Superintendent Compressor Stations, Lone Star Gas Company.

View of a modern compressor station, showing the general layout

tended to coil, which is now placed very close to the plug.

(3) Dust-proofing of valve cam cases and closer hooding of crossheads for dust protection, air cleaners on air-intake pipes to mixing valves, circulating water treated with Zeolite or other means to prevent scale formation, carefully designed baffles in water jackets to insure equalization of temperature at all points.

(4) All castings reflect greatly improved foundry practice. Exhaust valves, stems, seats, and bushings are now made of metals that have been proven adequate for that severe service. Improved lubricating oils that do not break down easily, applied at precisely the right points and in the proper quantities, have contributed largely to improvement in operation.

(5) The experience of automobile and airplane motor manufacturers in high-speed internal combustion engine development has pointed the way to many improvements in operation and maintenance, such as the careful selection of the metals associated in wearing surfaces, permitting the reduction of standard clearances and necessitating lighter lubricants.

(6) Great care now is taken to install means of cleaning the intake gas to compressor stations of all abrasives before entering the compressors, and greatly improved life of valves, piston rings, and liners has resulted. It also is noticed that the former shrieking noise made by gas passing through plate or strip discharge valves very largely has been eliminated.

The foregoing represents a considerable accomplishment in making this type of engine more dependable to operate and more economical to maintain.

There is a condition that the big engine does not meet, however, and that a similar type of engine, designed on a smaller scale but requiring a proportionate amount of investment in foundations, does not meet because of the lack of assurance of permanence of location. Often it is extremely desirable that these installations be made very quickly and without great cost beyond that for machinery. This demand has been met by the development of the angular type of engine compressors, combining the vertical multi-cylinder power unit with the horizontal compressor unit on the same bed plate, the bed plate being either cast as one unit, or in sections machined and doweled together, the compressors being driven by the crankshaft of the vertical power unit. Such units have been developed and are offered for sale by nearly all makers of gas-engine-driven compressors and are available in both 2-cycle and 4-cycle types. Much attention has been given to the technical detail in designing the 2-cycle type with the idea of obtaining fuel economy as near as possible to that of the 4-cycle type by means of better scavenging and fuel injection. It is the writers' understanding that these units have been perfected and are available up to 600-b.hp. capacity.

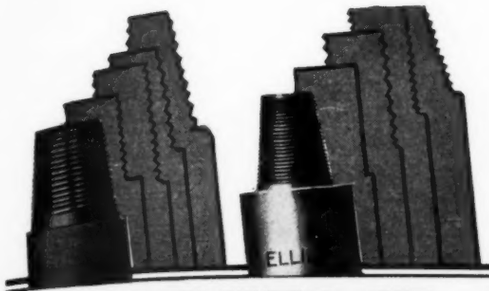
This type of unit has portability, it being possible with some sizes to move the entire unit by truck from factory to location. In larger sizes it might be necessary, to disconnect the compressor and compressor bed plate from the power unit and power bed plate, and when transported by truck to the location simply to skid the compressor portion up to the power unit, the dowels in the bed plate simplifying the alignment and making the services of an expert erecting engineer almost unnecessary, as the machine has been assembled in the factory and then dismantled for shipping.

Light foundation is required per hp. for this unit compared with the horizontal units, as the unbalanced forces are much less. The unit requires very little floor space, hence building requirements are much less, both as to square footage and for head room. As it is often desirable to place such units at various points in a field to handle individual wells or groups of wells, pumping directly into the pressure lines, it is so easy to equip this type of unit with safety devices that shut down the unit by grounding the magnetos in case of high-oil temperature, high-water temperature, high speed, or high pressure, and to equip with automatic draining devices when shut down that this becomes a very practical unit to use under such conditions where one man can look after a number of them, observing them at intervals to see that they are still operating, and if a maintenance job is in order fetch such help as is required.

Much research work has been done, a report of which just recently has been made public, on the application of machinery of higher speed, lighter construction, and higher efficiency to the compression of natural gas.

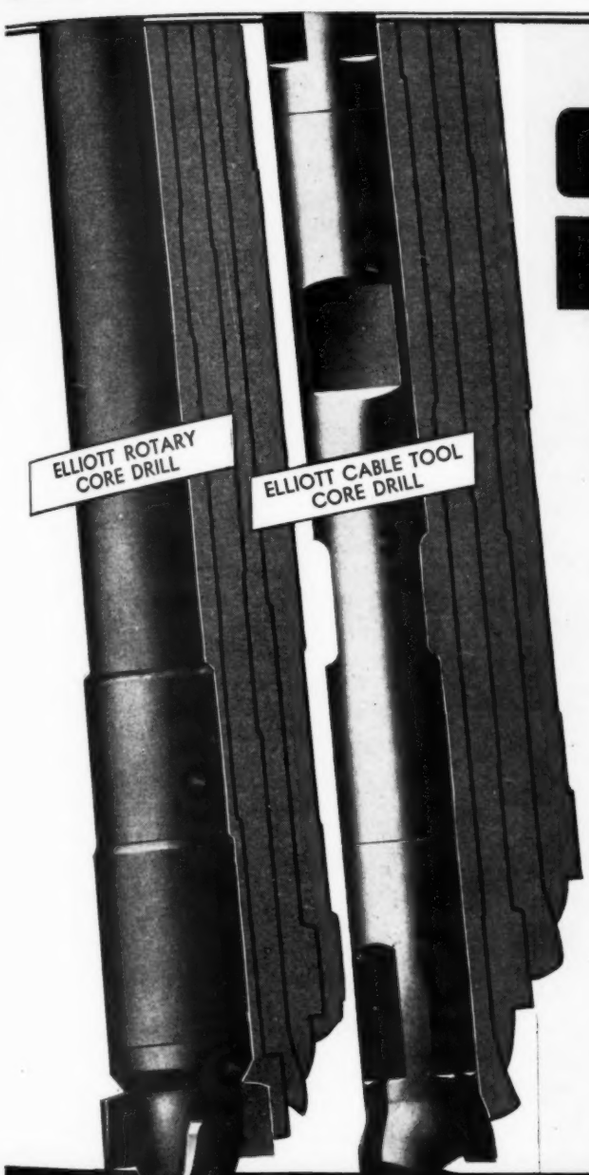
Machinery of this class includes the rotary compressor of the sliding-vane type, a type that has been used successfully abroad for some years but only recently has been accepted in this country. It seems to have a bright future, although possibly at this time it has its limitations. The industry will await with a great deal of interest reports on the few that have been installed for observation. This type of unit involves a high-speed rotor, slotted radially with vanes sliding radially in these slots, the rotor being arranged eccentrically within the cylinder, the cylinder and heads being jacketed although they may not be depending on the pressures and general operating conditions. When the rotor is placed in the cylinder, a crescent-shaped space is formed between the cylinder and the rotor. As the rotor revolves, the sliding vanes are thrown outward by centrifugal force, forming a number of cells corresponding to the number of vanes used and each cell starting from a minimum capacity and growing to a maximum, then decreasing to a minimum again with each revolution producing suction and compression. The rotor and shaft are supported in roller bearings, housed in the cylinder heads at either end, which also contain suitable packing glands and metal packing, effectively preventing leakage along the shaft where it emerges from the compressor.

Earliest designs of the rotary-type compressor encountered a discouraging obstacle in the considerable amount of friction developed by the vanes against



ELLIOTT'S *First-Hand*

CORING EXPERIENCE



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the cylinder walls, which lowered the mechanical efficiency, caused excessive wear, and limited the operating speeds. In order to overcome this obstacle the "floating ring" was developed and one was placed in either end of the cylinder. Floating rings are made in one piece and are slightly smaller in diameter than the cylinder bore, so that when the vanes are thrown out by centrifugal force they come in contact with the floating rings but do not touch the cylinder. The rings are so fitted into the cylinder that the friction of the sliding vanes upon them causes them to rotate at the same speed as the vanes. A slight clearance between the outer surface of the rings and the casing is filled with an oil film introduced under pressures from a mechanical forced-feed lubricator that also feeds oil to the end of the rotor. This oil spreads over the inner head faces and along the shaft to the bearings.

The rotary compressor does not become a positive-pressure machine until it has reached such speed that the vanes are thrown out by centrifugal force. It has very small clearances, which means a high volumetric efficiency. The multiplicity of the cells means that a constant flow of air or gas is discharged from the compressor without the slightest pulsation. We may see a rapid growth of the popularity of this machine, whose possibilities are so clearly evident.

Another development to which much engineering research has been devoted is the radial-type gas engine and compressor. Although much has been done in the development of this machine, considerable remains to be done. Recent reports are that to date it has not compressed up to any considerable pressure but its possibilities have awakened great interest. The unit consists of a multiplicity of power cylinders, four or eight in the experimental work reported, radially set in the same plane. The crankshaft is of the single-throw type, as all connecting rods operate on one crank. The master-rod and link-rod construction is employed. The big end of the master-rod is not split, has no separable cap, but is made as a continuous ring. To permit the mounting of the master-rod on the crank pin, the outer crankarm is made as a separate piece and is clamped securely to the extension of the clamp pin by a heavy clamp bolt. This crankarm carries a short section of shaft for the outer bearing and provision is made during its manufacture so that it always can be removed and replaced without the bearing getting out of alignment. The power is transmitted through the solid portion of the shaft. The removable outer section provides bearing support only, and, in the case of the engine, drives some of the auxiliaries. The power cylinders are of the 2-cycle design while the compressor cylinders are single acting and are fitted with long trunk pistons without the use of crossheads. They also are placed in the same plane and are either four or eight in number. The compression structure otherwise is very similar to that of the engine.

The same crankshaft and bearings, the same connecting rods and link-pins, etc., are employed. Similar provision is made for balancing both primary and secondary inertia forces. The crankcases are similar in form but necessarily different in details of construction. Both engine and compressor crankcases are secured to heavy supporting frames on both sides by through bolts. These frames terminate in feet that are bolted to the bed plate.

To eliminate the possibility of explosive mixtures being formed in the compressor crankcase from any leakage that might come past the pistons due to the single-acting cylinder construction, the case is tightly sealed and gas instead of air is maintained within it. As a safeguard against any infiltration of air, the gas in the crankcase is maintained at a slight pressure above atmospheric. To maintain the desired pressure within the crankcase a relief valve is provided and this may be piped out-of-doors so that no gas can escape within the building.

This type of unit is now available in sizes rated 500 hp. and 1000 r.p.m. and has been designed to meet the principal requirements of a modern compressor station unit and to effect a substantial saving in compressor station cost. It is noted that it will operate at a materially higher speed than is usual in present practice. Its compact construction will reduce greatly the floor space and building requirements. Its moderate weight and unit construction as far as possible will facilitate shipping and handling with a reduction in cost. It also will permit the use of lighter and less costly foundations, will reduce the time and expense of erection, and require less auxiliary equipment.

It is the writers' understanding that a few of these units are about to be placed in service, which indicates the interest that their possibilities have aroused. The entire industry will await with keen interest reports of the results obtained by this marked departure in design of compressor station machinery.

Exterior view of Northern Natural Gas Company's Clifton, Kansas, compressor station

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Controlled setting time	Normal UNDER 140°	Normal OVER 140°
High early strength	Drill out 1 to 2 days	Drill out 2 to 3 days
Sulphate-water resistance	Good	Exceptional sulphate resistance

The process of boring shot holes in the sandy bottoms of the Gulf of Mexico and inland waters is done by "jetting." This consists simply of forcing water under pressure through an ordinary pipe that is lowered by hand as fast as the water removes the sand from the hole. The holes stand up from 20 to 40 ft. in depth. (Photo courtesy of the Independent Exploration Company)

Progress of Geophysics

A discussion of some of the newer developments of geophysical exploration, both with regard to instruments and technique

By DR. J. BRIAN EBY

A REVIEW of the present status of geophysics in oil exploration shows clearly that the reflection seismograph is still the dominant method in use. The fact becomes apparent, however, that once again the science of applied geophysics is approaching an important cross-roads in its history. It will be recalled that from the year of its introduction into the United States, in 1922, to approximately 1930, geophysics, through the use of the torsion balance and refraction seismograph, enjoyed an indisputably important role in oil exploration. By 1931 both the refraction seismograph and torsion balance apparently had exhausted their finding possibilities and threatened to bring about the first crisis in the field of applied geophysics. The introduction of reflection seismograph shooting and its well-known phenomenal success most capably bridged this first indication of geophysical fallibility.

For the past nine years the reflection seismograph has been the backbone of geophysical prospecting. As the favorable oil field hunting grounds were successively covered by different oil and exploration companies and by progressively better instruments and methods, the resolving power of the reflection seismograph to find structures was being pushed to its absolute workable limits.

In the year 1936, in the Gulf Coast area alone, some 36 oil and exploration companies made use of 88 seismograph crews and covered approximately 20,000,000 acres. This would indicate that reflection shooting certainly is still a live and vital business. Notwithstanding this evident vitality the fact seems inescapable that geophysics once again is approaching a cross-roads such as it reached in 1930.

Two important avenues of progress present themselves as offering specific and definite advancement for the science of applied geophysics. The first would be the introduction and successful application of a new geophysical instrument or method. The second would be the opening to profitable exploration of huge new territories of potential oil production. The importance of finding new instruments, new methods, and new territory, has not been overlooked by the responsible executives of oil and exploration companies.

One of the newest types of reflection trailers equipped to handle as many as 12 independent detectors. (Photo courtesy of the Independent Exploration Company)

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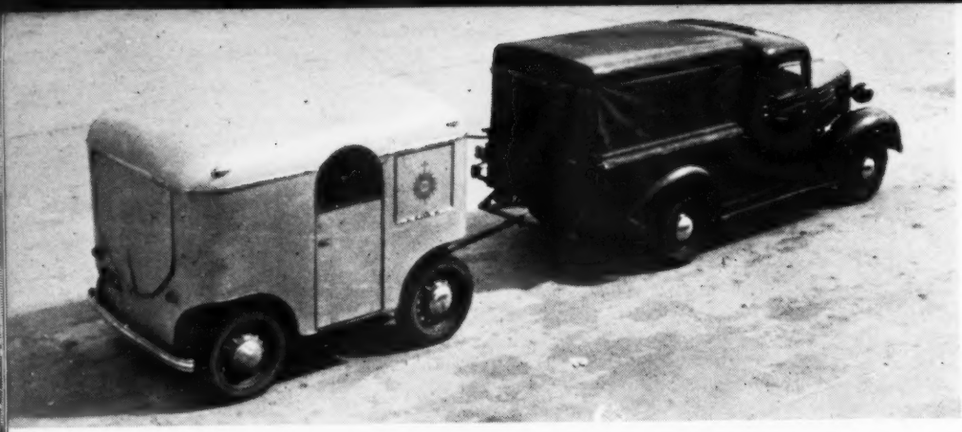


Truck and reflection seismograph trailer of newest design. (Photo courtesy of the Independent Exploration Company)

Reflection seismograph transportation in wooded lowlands of southern Louisiana. (Photo courtesy of the Independent Exploration Company)

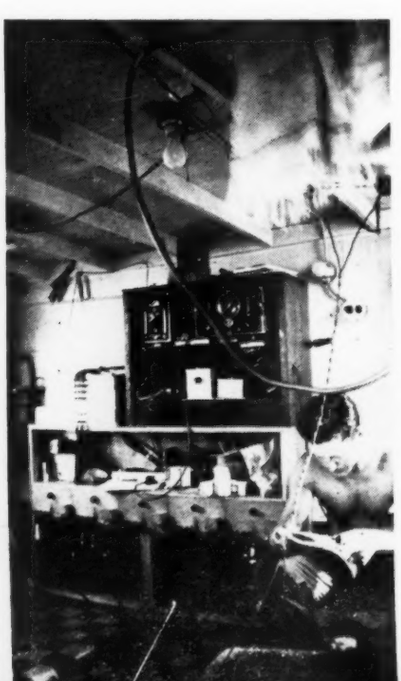
Before speculating further on future development, it is well to give a few words on the progress and development of present methods. As the burden of geophysical exploration is being borne largely by the reflection seismograph, some of the newer developments of this method, both with regard to instruments and technique, will be discussed.[1]

Concerning the instruments, there has been a tendency to construct smaller units, compact, and light in weight. A recently-constructed seismometer, or detector, was exhibited that weighed less than eight ounces and was of the size of an ordinary flashlight battery. Due to the rigors of marsh and swamp transportation, this reduction in the size of equipment has been of urgent necessity. The smaller seismometers require correspondingly less energizing currents and, therefore, fewer and smaller batteries. Considering the thousands of square miles of coastal swamp land, this question of the portability of instruments has been a serious one. It is of interest to point out that with the development of reflection shooting, the old mechanical seismographs practically disappeared. The heavy pendulum-type seismographs gave place to the electro-magnetic type detectors. This change also was a tremendous asset in handling swamp and water investigations.

Considerable effort has been expended on improving time devices. Tuning-fork control still is largely used. The actual error in timing has been reduced to the order of one thousandths of a second. Multiple seismometers are gaining in favor. In matching the different seismometer traces on the same seismogram, a tolerance of one thousandth of a second of time difference now is the usual requirement.

The use of electrical filters now is practically universal. It has been observed that sound energy of sufficient amplitude for satisfactory records has a lower and lower frequency with increasing length of travel through the earth. To receive these sounds, therefore, by detectors on the surface, which are subsequent to sound waves from random sources of higher or lower frequencies and of greater amp-

Reflection seismograph equipment mounted in a boat for water work. (Photo courtesy of the Independent Exploration Company)



Transportation methods for reflection trailer in Louisiana marsh land. (Photo courtesy of the Independent Exploration Company)

[1] A paper on the "Status of Seismology in Geophysical Exploration" was prepared by J. Brian Eby and Robert P. Clark and presented by Paul Weaver before the Eastern Section of Seismological Society of America, at St. Louis, Missouri, on Saturday, June 12, 1937.

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Preparing shot hole in Louisiana marsh land for reflection shooting. (Photo courtesy of the Independent Exploration Company)

litude, it is necessary to eliminate these random sound waves. Otherwise these random sounds, which constitute the so-called "noise-level," would mask the receipt of the waves through the earth.

In seismograph work the need for proper magnification and volume control became of great importance. With increased distance of travel through the earth, the energy rapidly decreases, so that if sufficient energy be supplied at the source to provide readable records from a deep-reflecting horizon, the records from a shallow horizon would be of such amplitude as to be illegible. A device, therefore, has been designed to increase the magnification progressively with time and, as recorded, reflections from shallow and deep beds will have the same apparent amplitudes.

Field practice has witnessed a steady experimental development toward improved methods. The demand for more and more refined information led to the system of continuous profiling. By this method the seismometers are spaced in line 150 or 250 ft. apart. The shot either is in line or at right angles to it and usually 2500 ft. distant. The spread of seismometers is moved forward progressively, the last seismometer in line occupying the former position of the leading detector after each successive shot. The lines may be extended at will. It is possible by this method to follow certain individual reflections over many successive spreads that would not be recognizable or usable in isolated shot locations. Naturally this exploration system is slow and expensive but the lack of consistent reflection beds in the coastal area justifies its use.

The planting of the dynamite charge has been the subject of investigation. From the early hand-drilled holes there has evolved the portable automotive shallow rotary well diggers. Now it is customary to plant the charge at depths of from 100 to 250 feet.

In marsh and swamp work it has been found advantageous to place the detectors against wooden beams, usually 2 in. by 4 in., that have been driven deeply into the muck. In open water it has been found quite satisfactory to fasten the seismometers to wooden posts so that the detectors are about two ft. below the surface.

With the improvement of methods and instruments has come a general improvement in the interpretation of results. An actual instance is of record in which the depth of deeply buried salt was predicted to within an error of less than ten ft. at a depth of 7200 feet. With the increasing use of continuous profile has come the identification of arbitrary or "phantom" reflection horizons. Frequent closing of continuous profile traverses permits the

Rieber sonograph analyzer and operator. Each trace on the drum in the right foreground represents the cumulation of ten sound tracks. The film on which the sound tracks are recorded is drawn from the cylindrical magazine in the lower left foreground to the upper magazine once for each trace on the drum record. (Photo courtesy of Rieber Laboratories)

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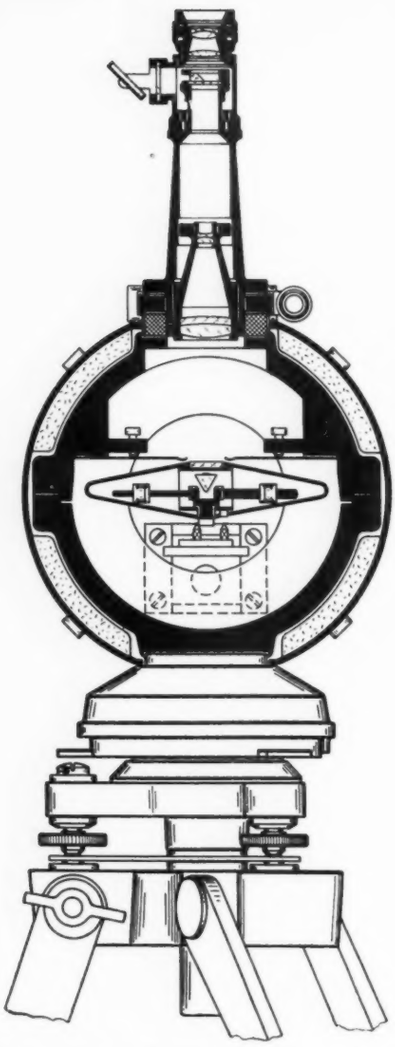


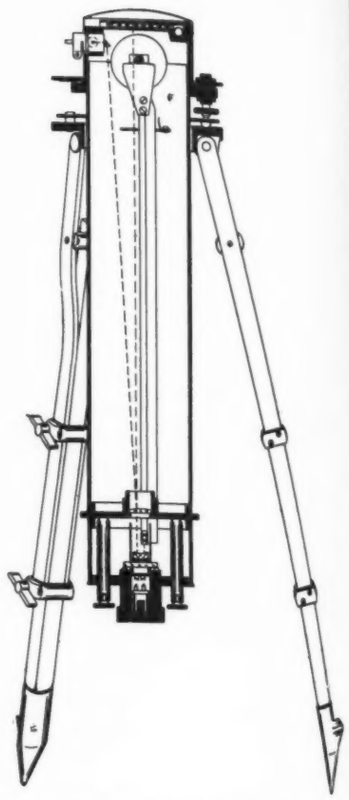
Cross-section through Askania vertical magnetometer, latest type; round casing provided for the installation of vertical or horizontal magnet system. Through improved optical and mechanical construction overall accuracy of instrument increased to plus or minus 0.1 p., corresponding to about plus or minus 1 gamma. (Photo courtesy American Askania Corporation)

seismologist to check the identity of particular horizons.

Considerable investigation by refraction seismology concerning the shape of known salt domes is now being carried out. In some instances the seismometers are placed on the surface and the shots fired in the well at various depths in the salt and above. The process more often is reversed, with the seismometers in the holes and the shots fired from different equally-spaced locations.

Within recent months the Rieber Laboratories, of Los Angeles, has brought to the Gulf Coast its Rieber Sonograph, a distinct departure from the usual reflection-type seismographs. With this instrument reflection waves are treated as sound waves and automatically recorded on a sound track, to be reproduced later in the laboratory and analyzed at will. A very complete and illustrated description of the method and apparatus is given in Frank Rieber's article in *The Petroleum Engineer* for February, 1937. Its practicability in the Gulf Coast has yet to be established.

Another variation of seismological research is being examined extensively by geophysicists of the Humble Oil and Refining Company. Dr. L. W. Blau, chief geophysicist, and Louis Statham, geophysicist, for this company, first suggested that there might exist a variation of earth resistivity with elastic deformation. Their definition of this effect, which they have described as "seismic electric effect," is given in considerable detail by R. R. Thompson, a co-worker, in the publication *Geophysics*, October, 1936. The author describes the electric circuit used to investigate the character, causes, and magnitude of this seismic electric effect. There is no specific data



Cross-section through portable recording magnetometer; instrument of light weight, and compact; to be used for vertical or horizontal magnet system; recording on standard photographic plates; sensitivity about 6.6 gamma for 1 mm.; one hour time interval corresponding to about 5.3 mm. on the plate. (Photo courtesy of American Askania Corporation)

Upper part of short period torsion balance with inclined beams, being carried by operator in difficult terrain. (Photo courtesy American Askania Corporation)

available on the performance of this instrument over any particular dome or structure.

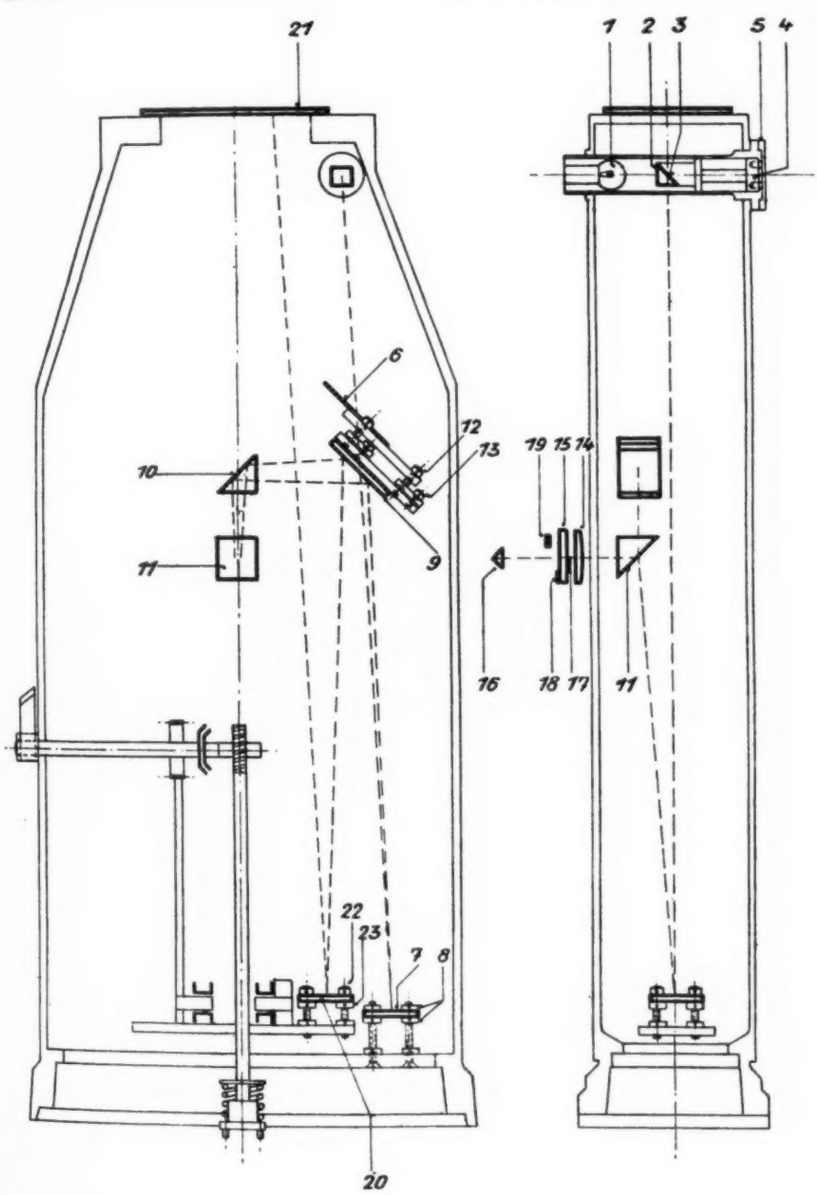
The torsion balance steadily has increased in favor within the past year. The introduction of the new inclined beam torsion balance, which reduces the time for making an ordinary field observation from several hours to approximately an hour and a half, has made it possible to make as many as eight observations a day. Much of the present torsion balance work now is being conducted by the various oil companies with their own staffs and the independent torsion balance contractor has almost disappeared from the scene.

A definite and general revival of torsion balance interest is evidenced by the fact that during the year 1936, in the Gulf Coast area alone, various companies used more than 20 torsion balance crews, consisting of almost 80 instruments, and explored a total of approximately 10,000,000 acres.

Much work has been accomplished on the direct measurement of gravity in the past by means of the pendulum. The standard of accuracy was of the order of one part in one million. Improvements to the instrument have increased the accuracy of the pendulum to approximately one part in six million. For several years many of the major oil companies have experimented with the pendulum in oil exploration investigations. During the past year, however, the gravitimeter seems definitely to have superseded the pendulum in geophysical exploration. Several of the larger companies have developed independently the gravitimeter to where it can be operated in routine field work with an accuracy of one part in ten million, or even better. In the Gulf Coast in the early part of 1936 there were in operation 17 gravitimeters that tested approximately 12,500,000 acres.

There are some indications that geophysical research in the Gulf Coast has reached, if not actually passed, its greatest peak. The entire area has been explored in reconnaissance and most of it in great detail. In a paper entitled "Discovery Rates in Oil Finding" in the June issue of the *Bulletin of American Association of Petroleum Geologists*, Wallace E. Pratt, formerly vice-president of Humble Oil and Refining Company, now director of the Standard Oil Company of New Jersey, points out that oil field discoveries have declined and that geophysics alone has not been equal to the task of finding as much oil as the older methods of wildcatting and geology. This statement bears out the sentiment expressed earlier in this article that geophysics is compelled to seek new instruments, new methods, and new potential territory.

The recent geophysical exploration activity in the Illinois Basin and the finding of oil in this territory certainly gives new life and impetus to geophysics. Several new methods of geophysical exploration now are in the process of extensive scientific experimentation and much is anticipated from this quarter. Considerable work is being done both by major companies and independent geophysicists on the examination of subsoil gases. It is too early yet to make any prediction concerning the outcome of these investigations. Needless to say the vast amount of geophysical activity now in progress and scheduled for the near future will keep the applied geophysicists busy for a considerable time to come.



Cross-section through portable short period torsion balance with inclined beams, showing essential details of optical system of such torsion balance; important parts well protected in central casing, easily accessible for adjustments. Feature: light weight and speed of operation. (Photo courtesy American Askania Corporation)

Tying in over a canal crossing on the 84-mile, 8-in. gas line recently laid between Casa Grande and Ajo, Arizona

Some rough going called for compound bends on the 84-mile, 8-in. Lindewelded gas line between Casa Grande and Ajo, Arizona

Progress in Oxy-Acetylene Welding of Pipe Lines

Advancements made in adapting the all-bell-hole welding method of pipe-line construction to a variety of field conditions

By S. C. CLARK[1]

MUCH worthwhile progress has been made in the year just past in adapting the all-bell-hole welding method of pipe-line construction, utilizing the Lindeweld process of oxy-acetylene welding to a variety of field conditions, particularly in connection with improvements in line-up and bending operations.

First, it should be explained that in the all-bell-hole welding method pipe lengths are individually lined up one after the other, usually over the ditch, and are then welded into a continuous line, each weld being made without turning the pipe. Bending, line-up, and welding operations all are taken care of by a crew working comparatively close together. With roll-welding or "storm-gang" construction, on the other hand, the line-up and welding gangs may be miles apart from the bending and laying gang, if the right-of-way is rough and many bends are required. This in itself explains one reason for the popularity of this newer method, because all operations are concentrated at one point, making supervision and the trucking of supplies much simpler.

An illustration of this is seen in the 178-mile 6-in. gasoline line laid in Kansas last year. The roll-welding gang completed its work approximately 100 miles ahead of the laying gang. They had been going at the rate of from 18,000 to 22,000 ft. per 9-hr. day, and due to rough going and the great number of bends required, the laying gang could not possibly keep up.

Roll-welding requires quantities of skids and dollies for lining up and rotating the pipe. A good-sized line-up gang with adequate mechanical equipment is needed to keep up with the pace set by the roll-welding. Line-up in hot weather is made none the easier by the "rainbowing" of the pipe due to the topside being heated by the sun more than the underside.

Although the daily mileage possible with one gang using the all-bell-hole method is somewhat less than with roll-welding, there are other compensations. It should first be emphasized that all-bell-hole welding is not exactly new, having been employed some 12 or more years ago for a few short ripple-welded lines, and for an extensive portion of a 6-in. water line in the far West some four years ago. With forehand ripple welding, however, the bell-hole welds took more than half again as long to make as roll welds so the method was not generally feasible.

Using the newer oxy-acetylene method that employs backhand technique and an excess acetylene flame, bell-hole welds now can be made almost as rapidly as roll welds. In fact, bell-hole welds take but 10 to 20 percent more time, and little, if anything, additional in the way of gases and rod.

Ordinarily this decrease in weld production per operator is more than made up by a general increase in efficiency of the construction gang as a whole.

As employed in the field, there are two general systems of all-bell-hole welding. The so-called "stove pipe" method gives the greater daily production. Joints are tack-welded as they are lined up over the ditch, and from two to six or eight operators, depending on daily production desired, follow in behind and make the welds in position. The "stab-on" method is the simpler. Two operators begin welding the joint as soon as it is lined up, eliminating the usual tack-welding. A simple procedure has been developed whereby one operator does not interfere with the welding of the other. When only one operator welds the joint, it is customary to put on about two tack-welds first, to control the spacing on the side opposite to which the welding starts. After a weld is completed, another length of pipe is lined up, and so on.

[1]Linde Air Products Company.

Making a bell-hole Lindeweld on a 6-in. oil line near Lyons, Kansas, constructed by "stovepiping." This weld takes but little longer to make than a roll weld

When bends are needed, the pipe is bent either in single-joint sections or in multiple-joint sections that are welded together in advance of line-up over the ditch.

In contrast to the older roll-welding organization, the bending and laying gang is moved up to the front end and consolidated with the line-up and tack-welding gang; the firing line and bell-hole gangs are consolidated into a

Multi-flame roll welding a 200-ft. section on the 178-mile 6-in. gasoline line laid last fall from Augusta, Kansas, to Kansas City

single bell-hole welding crew. Or, looking at it another way, it will be seen that the bending and laying gang simply handle 40-ft. lengths of pipe instead of 200-ft. sections, thus eliminating entirely the line-up and firing-line gangs. This gang makes bends where necessary, lines the lengths up over the ditch on skids, and tack-welds the joints ready for the bell-hole

A wrinkle bend made on a 10-in. gas line by heating a narrow band two-thirds of the way round the pipe with oxy-acetylene flames, and then pulling or sagging the pipe into a bend. Less mechanical equipment is required with this bending method

welding. Naturally, bending is a little different because of the shorter lengths handled, and the number of men bell-hole welding must be such as to get suitable daily production.

There is no particular difficulty with "rainbows" in the pipe, dollies are no longer needed because the pipe is not rolled, and all operations are grouped in a relatively short stretch along the line. The result is that better supervision can be maintained from front end to back end.

Advancements in the all-bell-hole method during the past year have been noted chiefly in smoother, quicker line-up operations, and especially in handling pipe that is to be bent to fit the ditch ahead of lining up the pipe for welding. The welding set-up also has been brought to a greater state of perfection.

On gas lines, the wrinkle-bend method of bending pipe to fit the ditch is becoming popular generally. A narrow band is heated a distance half to two-thirds the way around the pipe with oxy-acetylene flames, and the pipe is then bent so as to leave a wrinkle in the pipe wall projecting outward. This does not thin the pipe wall in any place nor reduce the effective cross-sectional area. Wrinkle-bending of pipe is in common use for high-pressure steam lines—a good indication of its suitability for high-pressure, high-velocity gas transmission. Wrinkles can be placed close together for short, sharp bends or they can be spaced more widely apart for the long, gradual ones.

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Fig. 1. The new type priming machine at work; several of these machines will be used on the Panhandle Eastern's new loop

Soil surveys more widely accepted—Protective coatings applied by special machines wherever possible—More extensive use of cathodic protection

Recent Developments and Trends in Pipe Protection

By GORDON N. SCOTT
Pipe Line Technologist, Los Angeles, California

ONE of the functions of writers on engineering subjects is to take stock periodically of the newer developments. Advantages of such "stock-taking" are that certain generalizations may be derived, misconceptions cleared up, and possibilities of monetary savings pointed out. General statements based on repeated successful experiences are invaluable to management in formulating policies in regard to engineering matters. Just as advertising creates "customer acceptance," so does "stock-taking" influence the general trend.

Of importance among recent developments has been the more widespread use of soil-corrosion surveys. A complete survey is becoming of even more importance now than formerly because of two factors: (1), some of the newer type machine-applied coatings are sturdier and more expensive than formerly; thus, their omission from a portion of the line where they are not needed may represent a large savings; (2), the extensive use of light-weight pipe tends in effect to exaggerate the corrosiveness of the soil; thus, soils that may be considered mildly corrosive with reference to standard-weight pipe need to be re-evaluated if light-weight pipe is to be used.

Among other developments, impossible to cover adequately in a brief review, may be mentioned the following: (1) Efforts to purchase materials on specifications and to check deliveries, and, (2), to extend tests on coating materials from those based on physical characteristics to those based on performance.

From the theoretical aspect, the greatest interest has centered in methods of determining the "condition" of a pipe line, involving such important questions as the relation of pit depths to the associated area, the rate of development of depth of pits, and the significance of these with reference to the wall thickness of the pipe.

In retrospect, the principal recent developments in pipe protection have pro-

Fig. 2. The pipe coating machine follows closely behind the pipe cradle

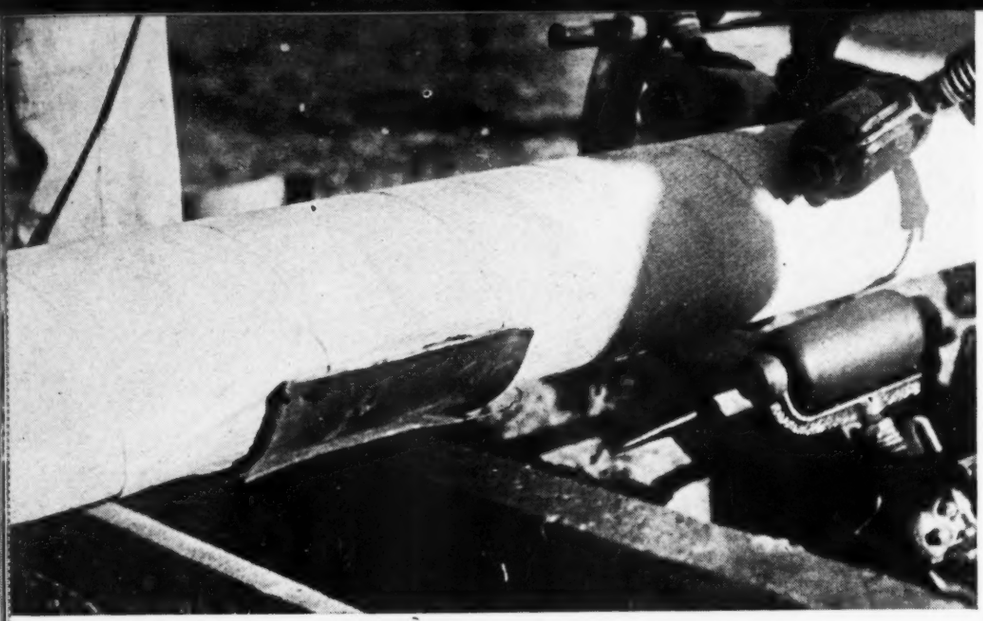

Fig. 3. The use of a protector interposed between coating and skid does away with the need for any subsequent patching of the coating

ceeded in two well-marked but highly divergent channels. These are: (1) a definite and advantageous movement toward the machine application of protective coatings; (2), highly important and significant extensions in the use of electrical protection. On the one hand, there has been the centralization of coating activities in fixed or mobile reclaiming or coating plants, for reconditioning as well as for new construction, together with a greater use of machines to improve the application under field conditions of coatings on made-up pipe. On the other hand, there has been the application of electrical protection to increasingly many miles of pipe as an anticipatory measure against a time of need in new installations, and as a practical alternative to reconditioning in old installations.

Soil Corrosion Surveys

Soil corrosion surveys are important in two respects: (1), to determine where to and where not to coat; (2), to determine what type of treatment can be applied most economically under the soil conditions that are encountered along the right-of-way. The more prevalent use of light-weight pipe, in effect, has extended the area of corrosive soils, as the "corrosivity" of the soil necessarily is linked to the wall thickness of the pipe. The use of thin-walled pipe not only increases the percentage of the line requiring treatment, but also places a more difficult burden upon the coating in that leaks are prone to develop more rapidly. Thus, in a given soil, in the absence of a coating, leaks appear in the lighter weight pipe before the shielding effect of the accumulated rust has a chance to slow down, or stop, the corrosion.

In soil corrosion surveys, the development has been away from placing dependence upon any one method of determining the corrosivity of the soil. No test has yet been demonstrated to be entirely satisfactory under all conditions. In addition to the laboratory methods that test the soil directly, supplementary field observations such as drainage, vegetation, irrigation, and topographical features are necessary in the interpretation of laboratory test results; further, experience in making and in interpreting soil corrosion surveys is a prerequisite for successful forecasting. In the hands of those skilled in the art, the percentage of correct forecastings is high and the savings to the company obvious because the necessity for the entire treatment of any line is highly improbable.

Important in the year's development of methods of forecasting corrosiveness has been that proposed by the National Bureau of Standards in which the electrical properties of the soil, as determined under certain test conditions, are used as a means of evaluating the soil's corrosiveness. This writer has pointed out (unpublished communication) that successful surveys can not be made in the laboratory only but must also be backed by the equally important field observations. To illustrate the point the following table is presented in which is shown the effect of the moisture content of the soil, a quantity readily estimated in the field, upon the relation between the loss of weight of test specimens and a laboratory estimate of the corrosivity of the soil.

TABLE I

Effect of Soil Moisture on the Relation Between Loss of Weight of Specimens Buried in Soil and a Laboratory Estimate of Potential Corrosivity

Potential Corrosivity	Soil Moisture Content (Percent dry weight of soil)		
	0-10	10-20	20-30
0.15-0.25	0.53	2.55	5.59
0.26-0.35	3.88	6.80	9.03
0.36-0.60	7.80	8.66	12.65

In some cases it is more desirable to leave uncoated corrosive areas of limited extent rather than to transport heavy equipment to the site under pressure of construction. Intentionally uncoated areas are economically rectified by means of cathodic protection, or by coating at a moderate expense at a later date when construction activity

Fig. 4. Illustrating in operation the mobile central plant, a Gulf Coast development

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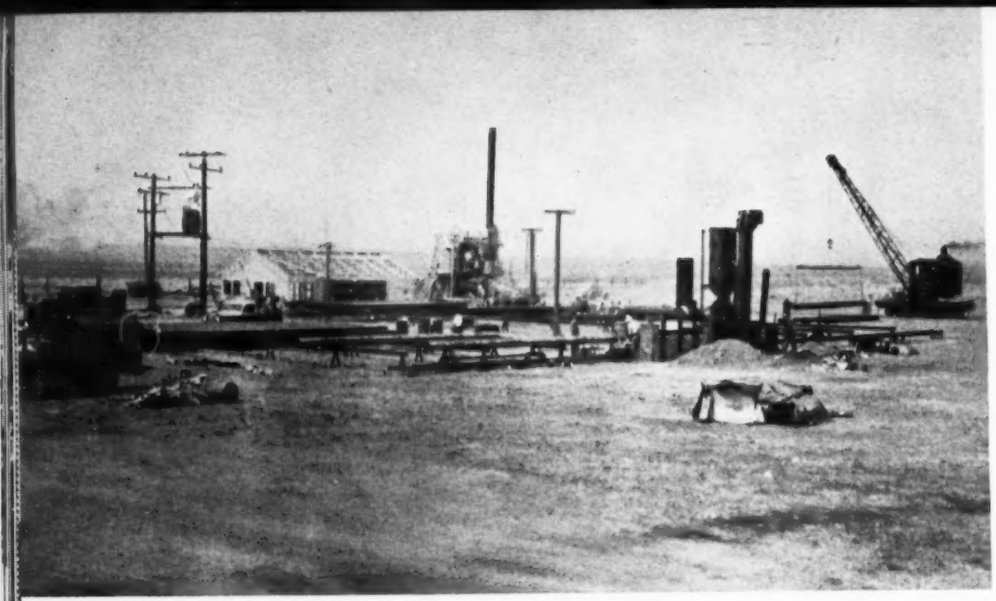


Fig. 5. The fixed central plant, a California project for marketing asphalt mastic

has subsided; in fact, new installations that do not provide for cathodic protection may lose an opportunity to procure an economic advantage. (In the writer's opinion, a modern reconditioning plan falls short of its economic objective if cathodic protection is not included in the program.)

A trend new to the oil industry is the purchase of certain coating materials on definite specifications. While it is necessary to set somewhat wide tolerances in the specifications, the purchaser at least is assured of a reasonably uniform product. The specifications center about the physical characteristics because they are readily determined. The purchase of materials on specification is old to the water industry, whose special methods of tests as related to the performance of the coating have demonstrated clearly the need for such additional control. Two materials having the same physical characteristics may exhibit totally different behaviors as disclosed by the performance tests. This trend in the matter of purchasing materials on specification has not been marked in the oil and gas pipe line industries, but a start has been made, and should be encouraged, as a greater uniformity in product and suitability for particular needs would result. An obstacle to attaining this desirable end is the difficulty of adequate sampling and testing in the field as the materials are received for immediate use on the pipe line. Opportunity for rejections therefore are slight. A possible solution, however, would be the testing for acceptance of the material at the plant before shipment, as is being done on one major project. The manufacturer may submit a certification of the properties of the material shipped, and the consumer may sample for analysis the material received. Thus, penalty for failure to conform within the limits of the agreed specifications later might be imposed.

Trend Toward Machine Application

The trend toward the use of machines in the application of protective coatings in the field has been marked. The advisability of cleaning new pipe before coating now is more generally recognized than formerly and many miles of new pipe laid during the past year have been field-cleaned by machine just prior to coating.

An entirely new machine for the field application of the primer appeared in the early part of 1936. In Fig. 1, the machine is shown in use behind a cleaning machine. The machine comprises a power-driven series of priming brushes and an independent forward-impelling mechanism that thus affords a wider application of mechanical priming. The independent character of the machine permits the regulation of the priming operation separately from the cleaning operation. The machine operates efficiently with little or no waste and permits the application of primers that cannot be satisfactorily applied by manual methods; thus, with the machine it is possible to use economically quick-drying primers of heavy consistency. Under reasonably favorable weather conditions, the pipe may be dropped and covered at road crossings almost immediately after priming and raised and coated later without the necessity for repriming. The design of the rotating head is such as to brush the paint well into all irregularities and to leave a thin, even coat on the metal. This factor, together with the properties of the primer, favor the desirable rapid drying.

While the application of the first coat of bitumen by the usual pipe coating machine is not new, the year has seen the adoption of its use by more companies. Its advantages are well-known and need not be detailed here, other than to state that the newer type of coal-tar enamels, commonly referred to as "waterworks enamels," can be applied by the machine without waste. The pipe coating machine is shown in use with a pipe cradle in Fig. 2. In the application of the more complex coatings, where a second coat of bitumen is applied, no mechanical means of application yet has been developed. The need for such a machine is apparent as then the application in the field of the entire treatment would be mechanical. Those who favor field application of protective coatings do so usually because of the important fac-

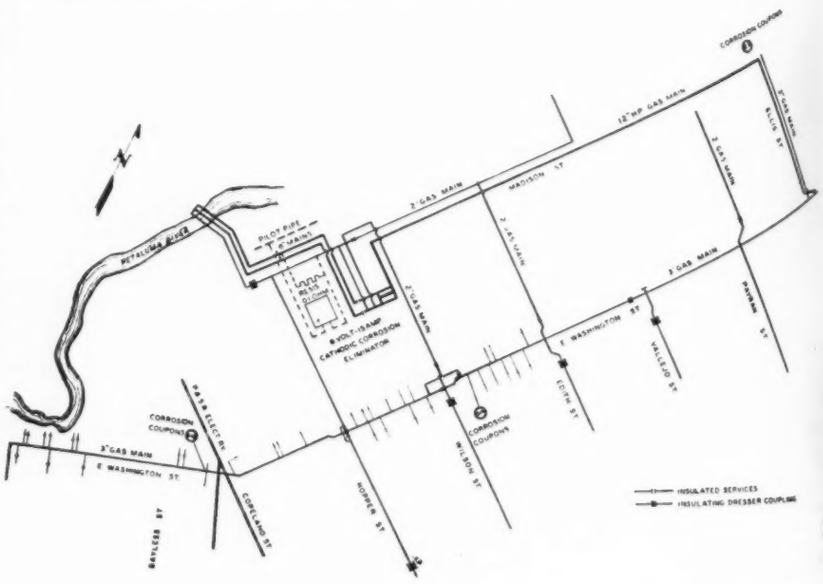
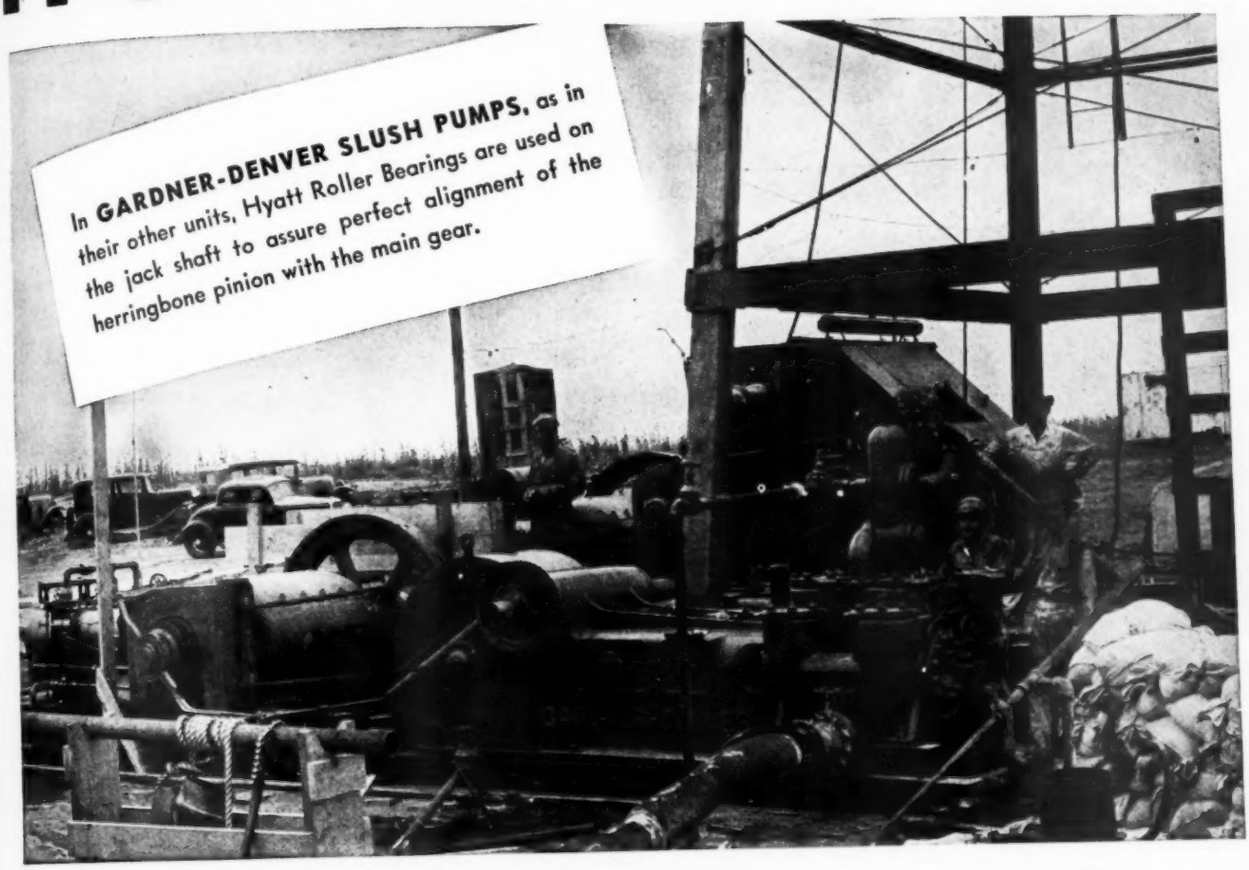


Fig. 6. A successful application of cathodic protection to a pipe network in the town of Petaluma, California

IT'S A TOUGH LIFE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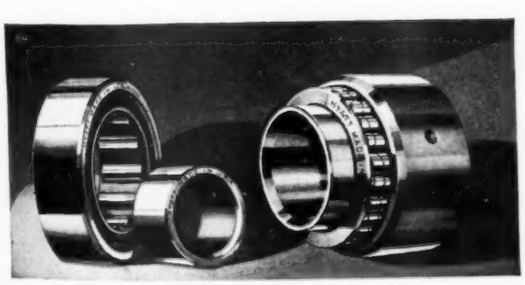

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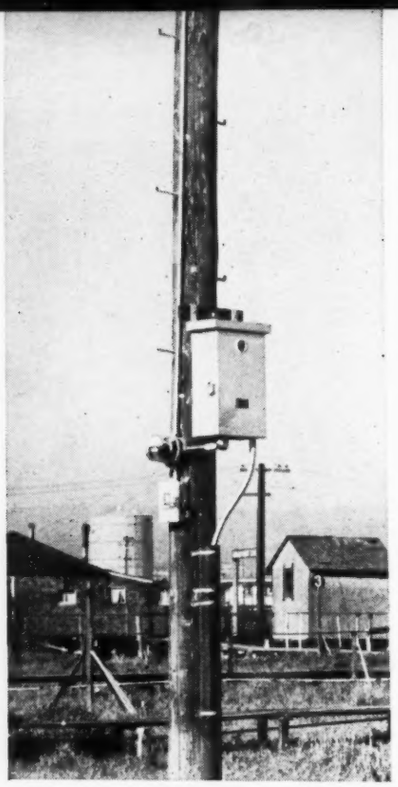

Fig. 7. A cathodic protection unit in operation near Oakland, California. Compare the small size of the unit with the service meter on the pole.

tor of continuity offered only by field-type machines. Because of this continuity, field application always will be important although some of the presently described developments tend toward centralization of coating activities. The use of the several machines mentioned or described, together with the familiar squirrel-cage wrapping machine for the application of certain shields and reinforcements, permits of considerable control in the application of the coating, both from the viewpoint of speed and of quality. As the rate of application ranges widely to a possible maximum of two or more miles per day, the coating work need not delay construction, as is often charged. If the application process is followed by immediate laying, and "slack loops" are provided at points of skid supports with shields, as shown in Fig. 3, negligible damage results to the coating. The shields eliminate the necessity for a patching crew. The degree of perfection attained in the finished coating is the degree of perfection desired.

Mobile Plants

Protective coatings have been applied at pipe mills for many years. Similarly, coatings long have been applied at centrally-located pipe yards. But the application of coverings by portable plants at points convenient for receiving pipe and close to the right-of-way is new. The pipe is received at convenient shipping points where it is cleaned, primed, and coated. The amount of transportation necessary to deliver the coated pipe to the right-of-way is small; hence, the chances of damage to the coating are minimized. When the hauling distance becomes too great, the plant is dismantled, moved forward, and assembled at a new focus of operation. The process obviously is applicable to a wide variety of coating specifications. In Fig. 4 is shown the mobile plant first developed for the treatment of approximately 200 miles of 10-in. line recently laid in Texas. The advantages of this system are: more perfect coatings, free from holidays; ease of inspection of the coating at all times; short hauls from the mobile central plants to the right-of-way; no loss of time due to weather conditions; use of local labor as a factor in good will; a high man-day production; controlled low cost of completed job.

Central Reclaiming Plant

A similar development is apparent as an outgrowth of the central reclaiming plant. The take-up of a large quantity of pipe, as from abandonment of facilities or from the consolidation of multiple lines, may justify considerable expense in the establishment of adequate reclaiming facilities. Provided that the character of the coating is such as to stand storage or that transportation is not required over excessive distances, a coating plant is ideally located where these reclaiming facilities have been established. Such reclaiming plants, both temporary and semi-permanent, are common; but the degrees to which reclamation practices (such as cleaning, straightening, repairing, culling, etc.) are carried are without uniform standards in the several sections of the country. The establishment upon a commercial basis of a coating plant, operated independently but in conjunction with the reclamation process, is new. This process is not to be confused with the normal reclaiming of pipe for coating for private consumption, such as have long been in use by the gas companies. The Pacific Coast has witnessed the establishment of two such plants within the last six months. One is at Kettleman City and the other at Watson, California. These plants are equipped to apply the well-known asphalt mastic. Although more or less permanent, these installations are semi-portable, in that when the quantity of pipe to be treated justifies, they may be moved to more strategic points.

Cathodic Protection

Cathodic protection is old in its conception; if we consider the cathodic burden now carried for many years by the street railways, cathodic protection is old in its application. The more recent installations of these electrical systems for pipe protection, in which the distinguishing feature is an anode independent of the tracks customarily used in the railway cases, were devised and sponsored by the gas companies. The oil companies later followed suit; now that there remains no doubt of the effectiveness of the method, and the experimental period is well over, the more conservative pipe line interests, such as waterworks, are quickly falling in line with the general trend.

The recent extensions in the electrical protection of pipes have overshadowed all other new developments in pipe protection. Some of these important extensions are:

(1) The protection of bare metal.
(2) Application to pipe lines lying within city limits and under pavement.
(3) Application to pipe networks.
(4) Improvements in methods and equipment.

The most prevalent misconceptions of this modern and efficient method of protecting underground or submerged structures should be stated clearly and refuted so that extension in its use may proceed unhampered. Earlier writers were unanimous in their opinions that cathodic protection would have no application to bare lines in view of the heavy currents theoretically required; however, the extensive application of cathodic protection by a large engineering firm to bare lines, by means of a system of distributed anodes, fostered interest in the subject and led to many applications to bare lines by the older single anode methods. Several pipe line companies both in the Mid-Continent and in the west, now are protecting bare pipe lines satisfactorily by electrical means. Even in such cases, it has been found that the current requirements are by no means excessive; under some circumstances, therefore, cathodic protection may become an inviting substitute for reconditioning and replacement. It should not be inferred, however, that electrical protection will replace the use of protective coatings in new construction except as a supplementary measure. In the light of electrical protection the need of good, substantial coatings is now more important than ever.

Further support of the fact that bare lines may possibly be protected economically by electric power is given by the experiments (unpublished) of this writer on 6-in. and 8-in. pipe lines submerged in salt water and partly buried in sand. These experiments in-

PRODUCTION ENGINEERS

Enthusiastically Endorse

HERCULES "OVERHEAD-PACKING"

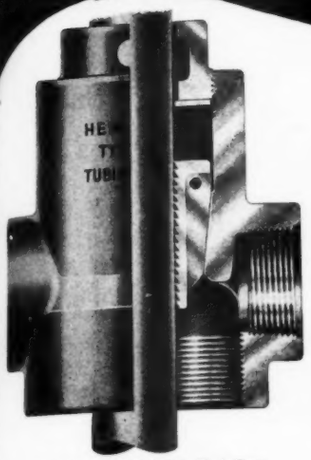

Fig. 208—HERCULES D-4 Cast Steel Tubing Head with Slips. "Overhead-Packed"

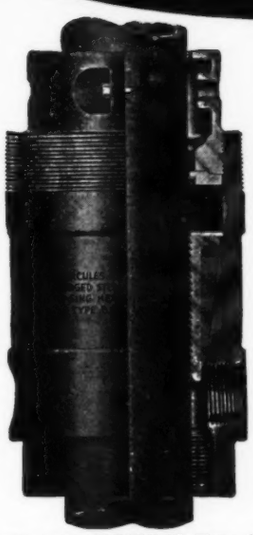

Fig. 101—HERCULES Type B "Overhead-Packed" Forged Steel Casing Head with Slips. Also made in Cast Steel

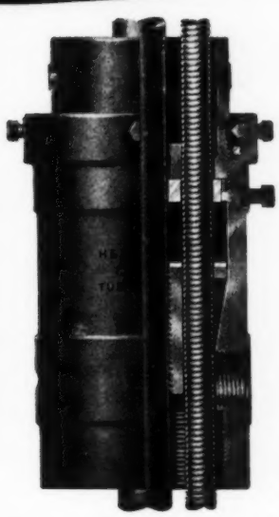

Fig. 210 — HERCULES Type R Forged Steel Tubing Head with Conduit for Cable for Reda Pump

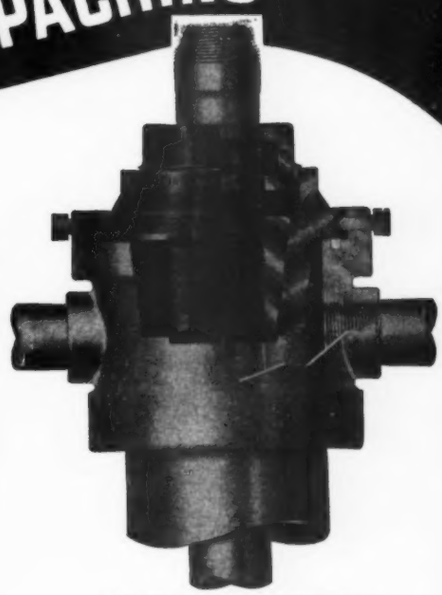

Fig. 216—HERCULES "Overhead-Packed" Tubing Hanger with Slips, sitting in Berry pattern casing head

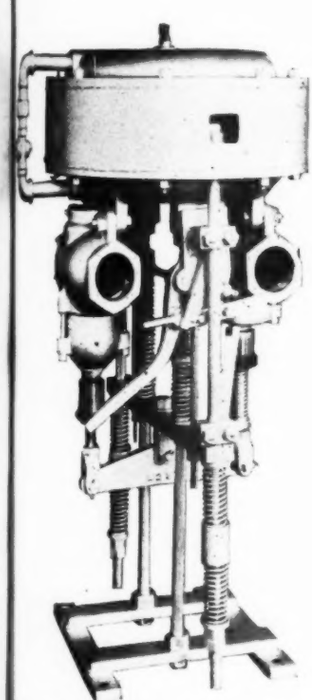

Fig. 214 — HERCULES Engine-Control Valve. Automatically or Manually Operated

Ever since HERCULES first introduced "Overhead-Packed" well head connections, production engineers have recognized in "Overhead Packing" a real engineering achievement. Overhead Packing offers three important advantages:

(1) Packing is protected, thus is not cut out or broken down; (2) Pressure on the packing can be instantly adjusted merely by turning the packing nut; (3) Head can be repacked without lifting the pipe or disturbing well hook-up.

HERCULES also wishes to call attention to *Two Valves* which we introduced a year ago, which represent new engineering developments. The HERCULES Engine Control Valve automatically protects Gas and Diesel Engines from *all* operating hazards, including over-heating, freezing and running off. The HERCULES Combination Globe-Relief Valve, installed in the flow line of a pumping well, maintains a constant back pressure on the fluid column within the tubing, and thereby (1) Eliminates paraffin in tubing and flow lines by preventing periodic flows; (2) prolongs life of rods and surface equipment by maintaining constant load; (3) Keeps polish rod cool.

See HERCULES Section, 1937 Composite Catalog, pp. 797-800.

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Fig. 215—HERCULES Combination Globe-Relief Valve

HERCULES

Oil Well Specialties

HERCULES TOOL TULSA

dicate that where a suitable anode is laid, or exists as an abandoned metallic structure, ample protection is possible at comparatively small cost, for power requirements are low, even though current densities at first sight appear high. The current densities required for complete protection of small specimens in salt water have been checked in the laboratory and the tests confirm the results of the writer's large-scale experiments. If it could be proved that the protection of bare metal in salt water can be accomplished at reasonable cost, the use of electric power to protect pipe in channel crossings would be an attractive substitute for replacement.

In the beginning practically all writers conveyed the impression that cathodic protection would find application only to well-treated lines, isolated in remote, rural districts. Though it is true that in certain cases hazards attend the use of electric protection in city streets and elsewhere, these dangers have been grossly exaggerated. Lines beneath pavements in cities successfully have been placed under electrical protection without the necessity of uncovering the lines, other than reaching them with slender rods for locating contacting structures and for testing purposes. A special technique has been developed for this work. Where neighboring pipe lines cross, or are closely adjacent to the structure to be protected, or make contact with the pipe at some point, special methods of protecting the line must be employed and sometimes access must be had to the pipe. It is necessary at times to insert insulating flanges in the line, bond over couplings, apply a protective coating, or introduce a metallic shield between the pipe line and another structure. Thus, though the pavement occasionally must be broken, the amount of such expensive work is reduced to a minimum.

In Fig. 6 is presented a typical example of cathodic protection applied to pipe networks in city streets. A portion of the town of Petaluma was placed under cathodic protection nearly three years ago and to date the application has proved successful. Although installations, such as this one, are of particular interest to the gas companies, the matter is of importance in the present connection to show the ability rapidly being acquired by engineers to effect the electrical protection of complex underground structures.

In the particular case shown in the drawing, there are no cross lines to complicate the problem. Under conditions where several differently owned pipe lines are involved, there will be need for close coöperation between the several utilities, or pipe line owning companies, to effect the maximum protection for all. Many companies have been schooled in such coöperation in electrolysis mitigation; when the application of cathodic protection has become more general, there will likely develop further coöperation. These cases will arise, not only in connection with pipe networks, but where many parallel lines share the same or adjacent rights-of-way or where cross lines occur.

Keeping pace with the extensions in the use of electrical protection has been the marked improvement in cathodic protection equipment. For example, the small size of a large capacity unit supplied by one manufacturer is well illustrated in Fig. 7, where its size readily can be compared to the service meter on the pole. In general, improvement has been procured, as one engineer points out concerning one piece of equipment, by:

"a) Reduction of installation cost
b) Increasing the reliability of operation
c) Increasing the efficiency and therefore the reduction of power costs (Fig. 8)
d) Decreasing the annual maintenance costs by reduction of inspection, overhauling, and replacement of parts."

Similar improvements have been effected in other types of equipment. One improved generating unit operates at high efficiency when driven by electric motor, by gas engine, or by wind. In the latter case, low starting velocities of from three to four miles per hour are required and moderate wind velocities of approximately ten miles an hour are required to develop full-rated capacities. The units are sup-

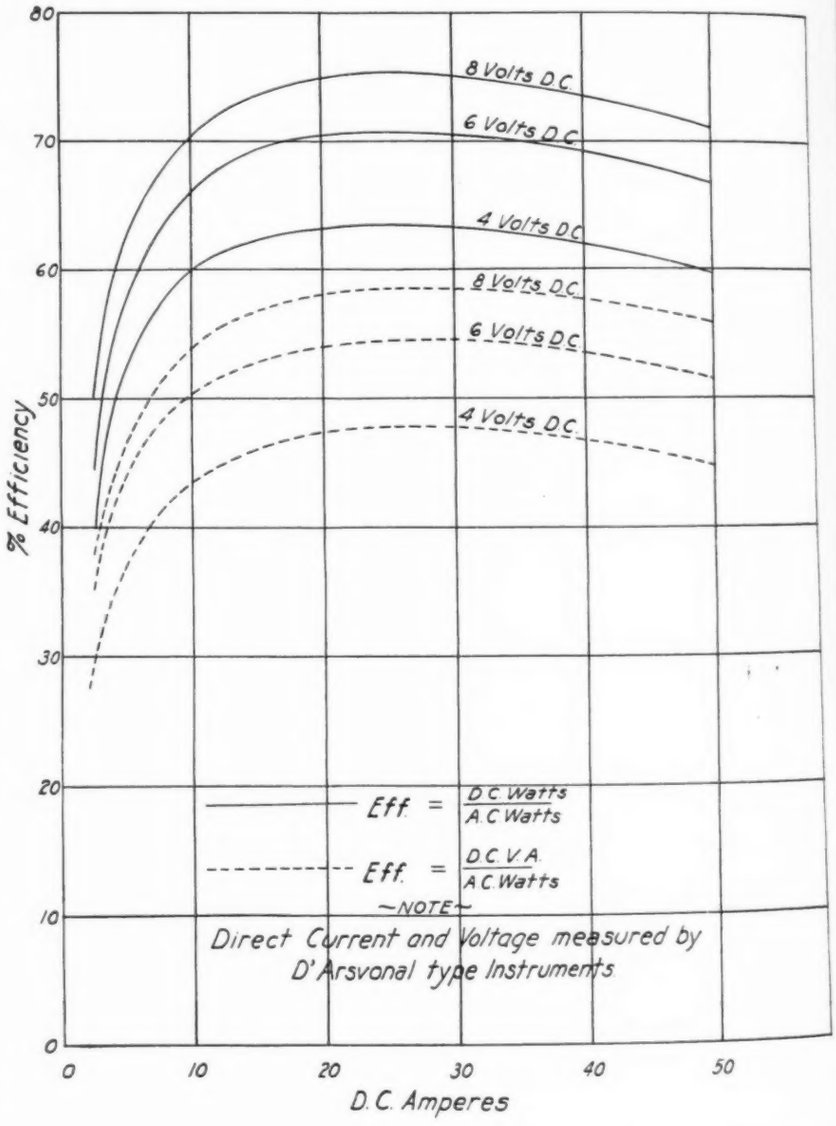


Fig. 8. The overall efficiency, including transformer of an 8-volt, 50-amp. unit

plied in several sizes, which permits of flexibility in motor power and capacity.

Conclusion

In writing this brief review concerning pipe protection, it has been difficult to refrain from interjecting prophesies into the text. Many enthusiastic predictions, therefore, have been deleted from the preliminary draft or left unwritten.

Speculative reasoning has its place, but only when in time the speculations take shape as realities is the author of the speculation honored. Apropos of this is the amusing, at the time, prediction of Williamson who in 1934 wrote: "It is my expectation to live to see the right-of-ways of transmission lines studded with windmills driving small dynamo sets similar to those now in our automobiles giving 20 amp. of low-voltage current for cathodic protection." To date, Williamson's guess has seen rapid fulfilment. From reliable sources the writer has learned that there are about 150 such cathodic protection units spinning in the breeze and daily delivering protective currents at low voltage to a great many miles of pipe lines in the Mid-Continent.

Perhaps in the present instance, it would be permissible to make one prediction as follows: A leak in the pipe line of the future will be attributable to human error.

AUSTRALIA'S CRUDE OIL PROSPECTS

KEEN interest has been manifested in the possibilities of obtaining petroleum on the continent of Australia and in the mandated area of New Guinea.

More than half of the Australian Continent is a low plateau of Archean gneiss and granite overlain by broadly folded but altered and mineralized Algonkian and lower Paleozoic beds unsuited to the occurrence of petroleum and natural gas. Possibilities of oil and gas in Australia are limited apparently to the basins of Mesozoic and Tertiary rocks downfaulted into the highly disturbed rocks of the eastern highland; to the gently folded Jurassic beds underlying the broad Artesian Basin of western Queensland and western New South Wales; to the Desert Basin in the northern part of Western Australia; the Northwest Basin of Western Australia; and the Gippsland Basin of southeastern Victoria.

Largely for structural reasons attention of geologists has been drawn to the Great Artesian Basin, especially on its eastern margin. In 1900 when a well at Roma, Queensland, was deepened to increase its flow of water, gas was produced from a depth of 3683 feet. A second well, begun in 1907 for oil, yielded in 1908 a large flow of gas that was ignited by the boiler fire and burned for five weeks. Drilling was resumed in 1916. A flow of "wet" gas was obtained for a number of years, and since 1927 small quantities of light oil. In 1931 about 7500 gal. of gasoline were extracted from the gas at Roma. In 1935 a flow of gas was obtained at Warooby Creek, ten miles east of Roma. No oil had been found to the end of 1935, but drilling located structures considered promising.

The only production of petroleum in Australia comes from the coastal plain of southern Victoria. In 1924 gas was found in a well put down at Lake Bunga, four miles east of Lakes Entrance. Since 1930 insignificant amounts of petroleum, emulsified with artesian water, have been obtained from wells, drilled to the Oligocene, at Lakes Entrance in the Gippsland district of eastern Victoria.

In contrast to the absence of liquid petroleum in commercial quantities, the Commonwealth is rich in oil-bearing shales. In Tasmania, near Latrobe, northwest of Launceston, a Permo-Carboniferous oil shale seam four to seven ft. thick has been mined since 1910, and the oil shale treated in a distillation plant at Latrobe. The average grade yields about 40 Imperial gal. of crude oil per long ton of shale. The sulphur content is somewhat high, being from two to three percent in the raw shale. The extraction of oil shale in Tasmania rose from 833 metric tons in 1925 to 5515 tons in 1930. In 1934, however, it had declined to 3329 tons, and in 1935 only 36 tons were mined.

In New South Wales a "kerosene shale" resembling Scottish torbanite, occurs in the Capertee and Wolgan valleys, within 100 miles of Sydney. The seam is from one to 54 in. thick and yields 101½ Imperial gal. per long ton of shale.

In 1905 the Commonwealth Oil Corporation began mining the "kerosene shale" at Newnes, N. S. W., and built a refinery to retort the shale and refine the crude oil obtained. To encourage the industry the Commonwealth Government offered a bounty of £10,000 for the year beginning July 17, 1910, and of £20,000 for the two following years, for the production of crude shale oil, and of 2s. 6d. per quintal for paraffin produced. Under this subsidy the production of "kerosene shale" rose to a peak of 87,394 metric tons in 1912. Faced with high costs and the competition of imported petroleum the production of oil shale declined to 23,842 tons in 1922, and production ceased in 1924 after 652 tons had been extracted.

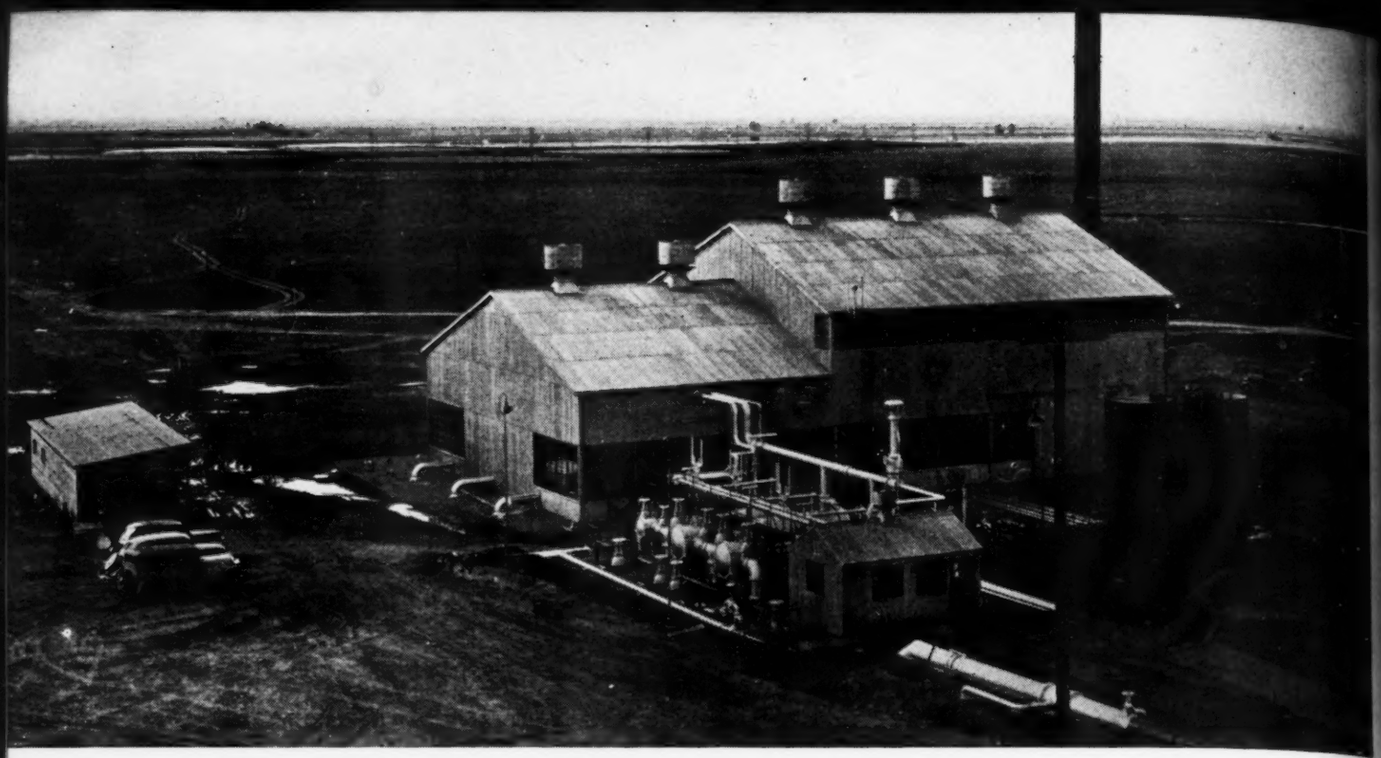
After the mines had lain idle for several years, the Commonwealth Government in 1931 instituted a Shale Oil Committee and appropriated £93,000 for prospecting. A production of 2032 metric tons at Newnes and of 1524 tons in Baerami were obtained in 1932, and a yield of 2871 bbl. of crude shale oil. In spite of official encouragement, however, the industry languished. No "kerosene shale" was mined in 1935. Increasing costs of mining, the use of equipment designed originally for treating Scottish shale with a lower yield, and the competition of cheaper imported petroleum products have placed the oil shale industry of New South Wales at a disadvantage.

Production of Crude Petroleum in Japan

SINCE 1874 approximately 69,000,000 bbl. of crude petroleum have been produced in Japan from a belt of folded upper Tertiary marine beds along the western coast of Hokkaido and the Honshu Islands. In addition, approximately 820,000 bbl. have been produced since 1900 in the western part of Taiwan from folded Tertiary beds. Greatest production was in 1916 when 2,962,000 bbl. were produced. By 1935 production had declined to 1,846,000 barrels.

On the Island of Honshu crude oil ranging in gravity from 12 deg. to 45 deg. A.P.I. is produced in the prefectures of Niigata and Nagano from gently folded, little faulted beds. In the prefecture of Akita gravity of the crude is 20 to 23 deg. A.P.I. and is obtained from Miocene shale formations at depths from 500 to 2500 feet.

For years the shallow depth of the wells made expensive drilling equipment unnecessary. In recent years, however, the primitive hand-drilling methods have been supplanted generally by the use of American standard percussion and rotary drilling equipment.



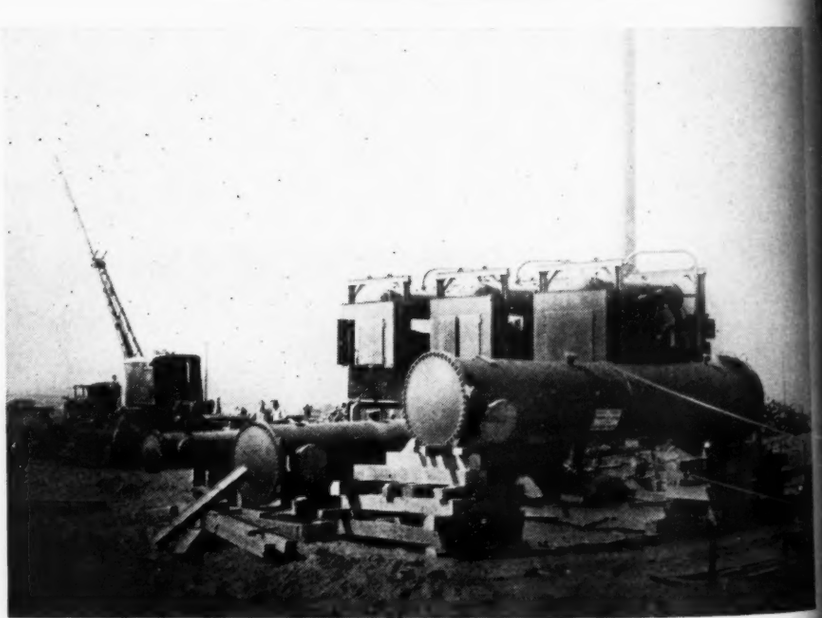
Bakersfield pump station, Shell Oil Company lines. Outside the main building can be seen the three heaters used for raising the temperature of the oil to 180 deg. fahrenheit

New Pipe Line Stations in California Unusual in Design

By WALLACE A. SAWDON

Design of trunk line stations constructed during past year illustrate the adaptability of equipment to meet specific conditions

ALTHOUGH pipe line construction in California during the past year has not involved the laying of many new trunk lines, station design and construction on the two major projects that have been completed during the period depict the adaptability of different kinds of equipment to meet specific conditions. Two new stations on the Union Oil Company's line from the Santa Maria field to tidewater at Avila are probably unlike any other pipe line stations yet constructed; but they meet effectively certain definite requirements that may sometimes be encountered at other localities. The four new stations and additions to six old stations on the Shell Oil Company's line from Bakersfield to the refinery at Martinez also are of advanced design, and these, too, meet the demands of specific conditions. The stations on



Boilers in process of erection at one of the Shell Oil Company's new stations. In the foreground can be seen the heaters not yet moved into position

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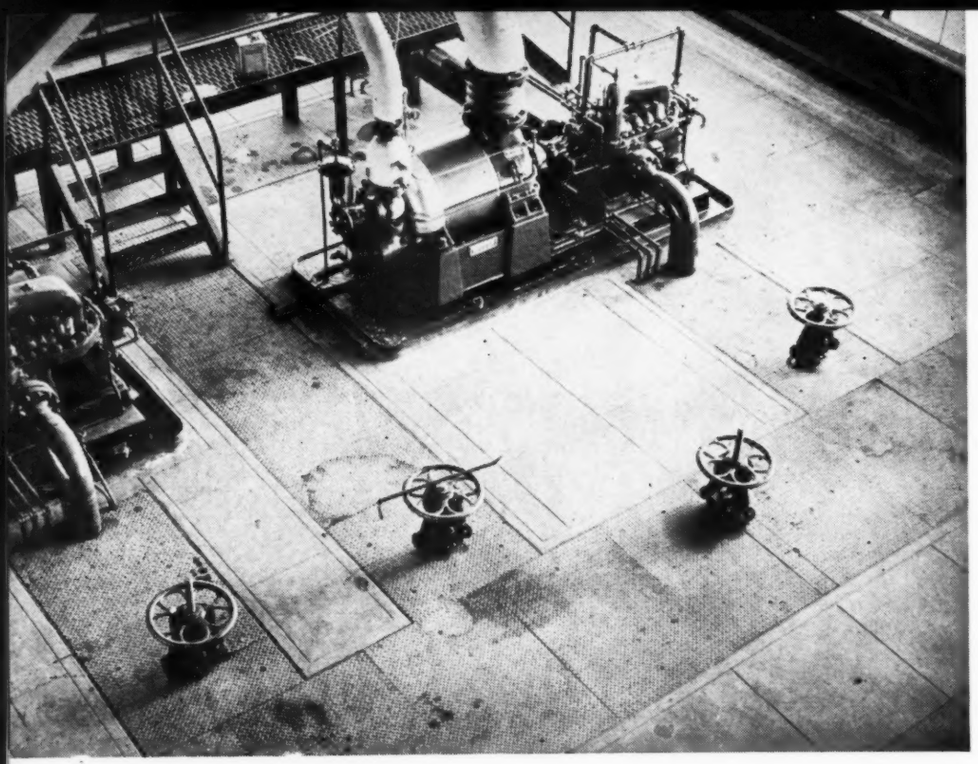


Interior of one of the new Shell Oil Company stations. Note the ample floor space and the wide distance between control valves. Piping is in concrete trenches equipped with steel floor covers

both projects serve hot-oil lines and both are governed in operation by the necessity of handling viscous oil. Other factors, however, have made the use of different types of main pumping equipment on the two lines desirable.

The Union Oil Company's stations are on a short line of less than 30 miles in length, as shown in Fig. 1. This line transports all the oil from the Santa Maria field to Avila, where it is shipped out by tanker. Many of the wells at Santa Maria had to be shut in upon completion until this line was put into service. Actually only a little more than two miles of new line had to be laid, as an old 8-in. line from Orcutt to Avila was available. A main pump station therefore was built at Santa Maria and a line from it laid to tap the old line at a point about four and one-half miles north of Orcutt. An intermediate station was placed at Summit, halfway between Santa Maria and the terminal at Avila.

An outstanding feature of these stations is the heating of the oil with direct-fired heaters. The oil handled has a gravity of 16 deg. A.P.I. and is highly viscous. Because of the high viscosity, it was essential to provide a means for heating the oil to any temperature necessary for pumping and it was believed that a direct-fired heater would essentially is a large still as indicated meet the requirements most satisfactorily. One heater of this type, which by an accompanying photograph, therefore was erected at each station. The heaters are equipped with forced draft and can burn either gas or oil.

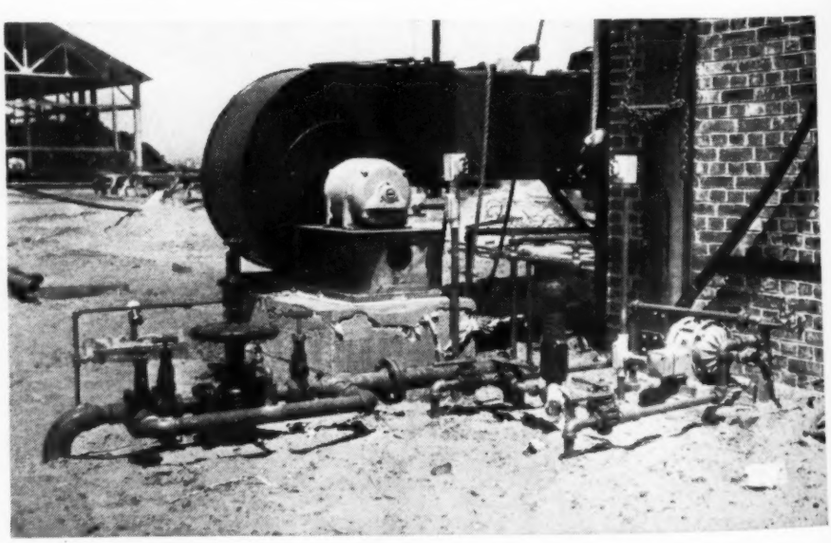
The main pumping equipment at each station consists of two Byron Jackson centrifugal pumps that together are capable of handling 1000 bbl. of oil an hour against a pressure of 800 lb. per sq. in. under winter conditions. During summer weather the capacity is 1200 bbl. an hour at a lower pressure. Each pump is driven by an 8-cylinder, 300-hp. Clark gas engine. Jacket water for the engines is cooled by circulating from a cooling tower, this water being kept in a closed system. A pressure of 100 lb. per sq. in. is maintained on the suction of the centrifugal pumps to prevent vaporization of oil in the pump. The discharge is into the 8-in. line carrying the oil from the field to Avila.

At the Santa Maria station the oil from the tank is carried through a 16-in. line to a separate pump house in which two Kinney rotary pumps driven by Hall-Scott 100-hp. gas engines are situated in a pit. One of these pumps takes the cold oil from the tank and boosts it through the heater. The other pump by-passes the heater.

In the heater the temperature of the oil is raised to 270 deg. fahr., but a portion of the heated oil—about 200 bbl. an hour—returns to the tank. This hot stream can be made to enter the tank either at the point where the suction line connects or in the center of the tank to heat the entire body of oil. When it is desired, an entire tank of oil can be heated before pumping operations begin.

The remainder of the hot oil stream passing from the heater is joined with the oil by-passed from the other rotary pump and the two streams mixed. This mixed stream then goes to the main pump house and into the suction of the two centrifugal pumps.

At the Summit station the same equipment is employed but all the pumps, rotary and centrifugal with their gas engine drives, are in one pump house. The stream of oil from the pipe line here enters the suction of the rotary pump with a tank floating on the line for relief. As at the main station at Santa Maria, one rotary pump boosts the oil through the heater but all this oil then joins with the by-passed oil



The forced-draft system with electric motor is shown on a heater, Union Oil Company pipe line station Summit, California

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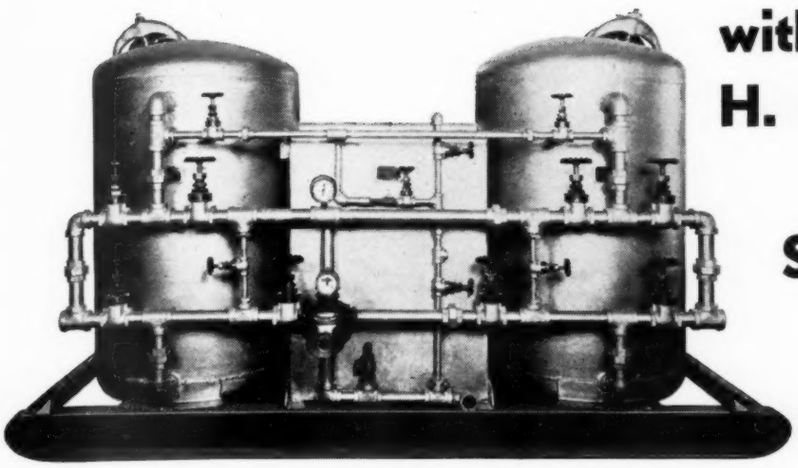

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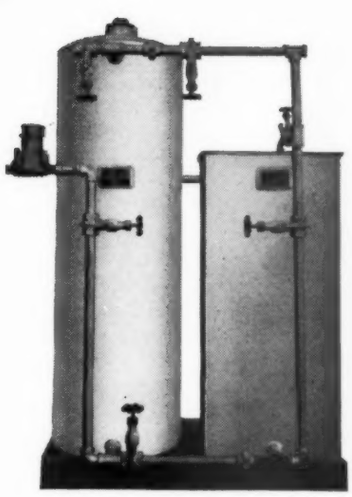

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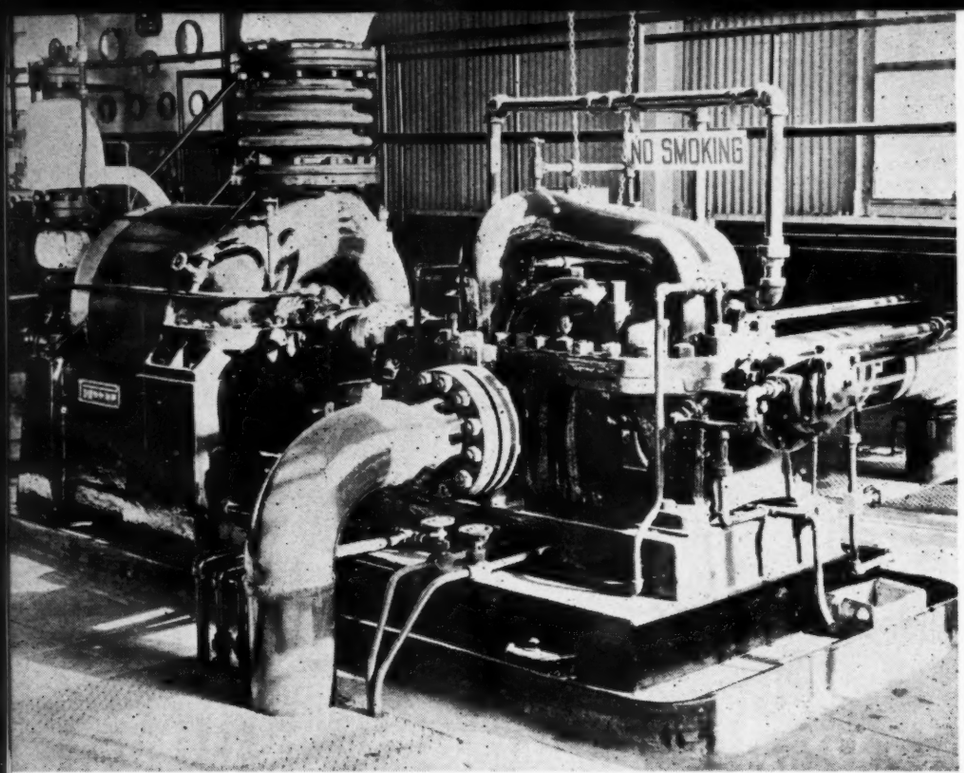

A main steam-turbine-driven centrifugal pump with control instrument board in the background

and the mixture put into the suction of the centrifugal pumps.

The reason for selecting this type of equipment, in addition to the necessity arising from the highly-viscous character of the oil, was that at Summit station there is very little water available at a reasonable distance and the amount is not enough for boiler-plant operation. A quantity of excellent spring water sufficient for cooling the gas engines, however, is readily obtainable.

The construction of the Shell Oil Company line from Bakersfield to the refinery at Martinez has been described in detail in a previous article.[1] The general location of the four new stations and the six old stations to which additions were made are shown in Fig. 1. The line distance from Bakersfield to Martinez is 258 miles and the distance between stations is indicated on the map. The new pipe line consists of 10-in. and 12-in. pipe, with the 10-in. line increasing to 12-in. at approximately two-thirds of the distance between stations.

The new line parallels an old combination 8-in. and 10-in. line from the station near Coalinga to Martinez and the existing stations on that line were increased in capacity to meet the demands of the new line. Oil of all gravities is pumped through the old stations but the most viscous oil naturally was the controlling factor in the design of the new and re-design of the old stations. The new combination 10-in. and 12-in. line carries the hot oil, while the old combination 8-in. and 12-in. line is operated as a constant-temperature light-oil line.

The capacity of each new station is 1200 bbl. an hour of the heaviest crude at a temperature of 180 deg. fahr., and against a pressure of 1000 lb. per sq. in. in extreme weather conditions. The main pumping equipment consists of three Ingersoli-Rand 4-stage, 6-in. centrifugal pumps driven by 350-hp. Moore steam turbines.

Steam for operation is supplied by three Heine type boilers with superheaters, operating at a pressure of 200 lb. per sq. in. and 100 deg. fahr. superheat. Each boiler is equipped with gas and oil burners. All pumping and auxiliary equipment is housed in a structural-steel frame and corrugated-iron building having dimensions of 59 ft. by 100 ft., with boilers and auxiliaries separated from the main pump room by a fire-wall. Control instruments are located conveniently in order to facilitate operations.

As can be seen in an accompanying photograph, three heaters were erected outside the main building. Two of these are 48-in. diameter low-pressure heaters with tubes 20 ft. long and a heating surface of 6225 sq. feet. The third is a high-pressure heater of 26-in. diameter with tubes 18 ft. long and a heating surface of 1422 sq. feet.

In order to increase fuel economy, so that during periods of exhaust steam surplus not required for raising or maintaining the temperature of the oil being pumped, the entire plant may be operated full condensing. This is accomplished by use of a jet-type air pump that maintains a high vacuum on the main oil heaters and by an automatically-controlled, electrically-driven condensate pump.

At the three new stations northwest of Bakerfield no floating tanks are provided. The incoming oil is directly connected to the main pump suction but may go through the heaters or by-pass them. The main pump steam turbines are equipped with pressure governors so regulated that a back-pressure is maintained on the heaters or suction sufficient to insure flooded suction conditions, and automatic regulation of pump output in step with the upstream suction. At each of these three stations there are two 15,000-bbl. steel service tanks, two 1000-bbl. steel water tanks, and two 144-bbl. fuel oil tanks.

[1] "Modern Engineering Features Embodied in California's Newest Pipe Line System," by F. B. Simms, *The Petroleum Engineer*, February, 1937.

One of the 8-cylinder, 300-hp., gas engines with maximum speed of 550 r.p.m. driving a centrifugal pump. Union Oil Company station

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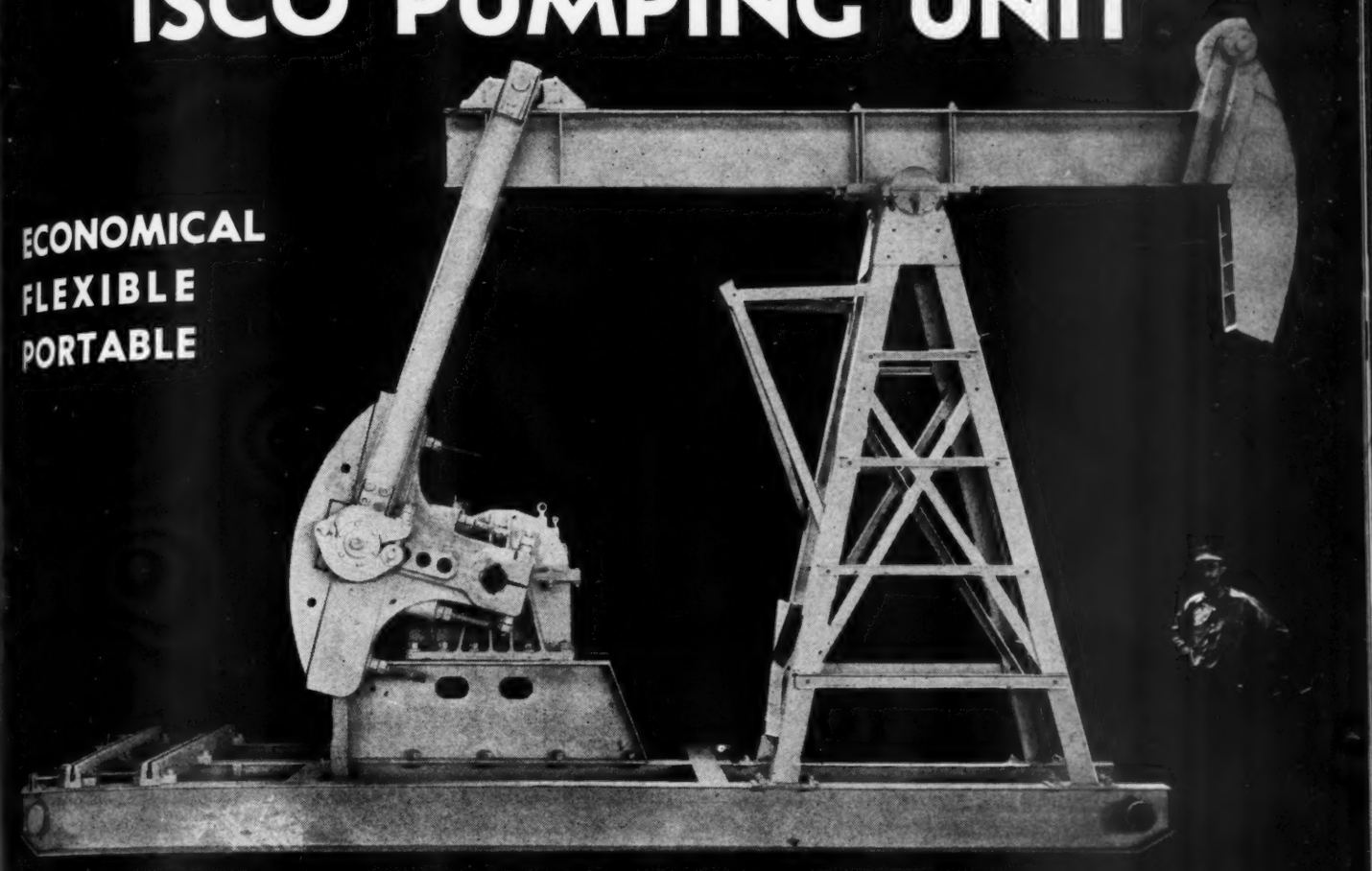

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One of the direct-fired heaters used on the Union Oil Company's line; photograph taken during construction

At the Bakersfield station the output is manually controlled. The oil flows into this station from a tank farm so situated that there is a suitable gravity head on the pump station through a large-diameter suction pipe system.

Wherever it has been possible, piping outside the buildings has been placed above ground or in open trenches. Within the pump houses all piping is laid in concrete trenches equipped with steel floor-plate covers, as shown in an accompanying illustration.

In adding to the six old pump stations between Coalinga and Martinez, it was decided to use the existing crank and fly-wheel type of steam-driven plunger pumps as the main pumping unit for the hot oil. To care for the increased oil passing through each of these stations, however, one Byron Jackson 4-in. by 6-in., 6-stage multiplex centrifugal pump was installed. This pump is directly connected to a 390-hp. Westinghouse steam turbine and is capable of delivering 1200 bbl. an hour against a line pressure of 800 lb. per sq. inch. Both the new centrifugal pump and the crank and fly-wheel unit are so hooked up that either may pump hot or cold oil and operate on either of the two lines. An existing Jeannesville straight-line plunger pump will be maintained as a standby for the other two main pumping units at each station.

In order to move efficiently the increased volume of oil going through each of the old stations, a 238-hp. Heine type boiler without superheaters was installed. This boiler was equipped with combination oil and gas burners and gas burner rings were provided for the old Heine boilers. Fuel oil, previously used, has been superseded by gas with which all installations now are being fired.

Three new oil heaters of the type described also were installed at each of the six old stations. The heating of a larger quantity of oil to 180 deg. fahr. instead of the smaller quantity to 140 deg. fahr., as provided in the old station design, is expected to be accomplished by the steam-turbine-driven centrifugal pumps that will provide additional exhaust steam to maintain thermal balance on the hot oil side while actually pumping cold oil. The originally-installed heaters remain connected through a small floating tank to maintain a constant low temperature on the original combination 8-in. and 10-in. light-oil line.

A floating tank, 40 ft. high and with a capacity of 720 bbl., was connected to the suction line between the outgoing side of the heater group and the pumps to insure flooded conditions in both heaters and pump sections. Incoming hot oil in the new combination 10-in. and 12-in. line is connected directly to the cold side of the heater group.

In changing the six old stations to meet the demands of increased capacity, several small additions were made to buildings and a considerable amount of change made in the suction, discharge, and auxiliary piping. The work was accomplished with the existing line remaining in operation, and required but two shut-downs of 12 hours each, and one of 30 hours.

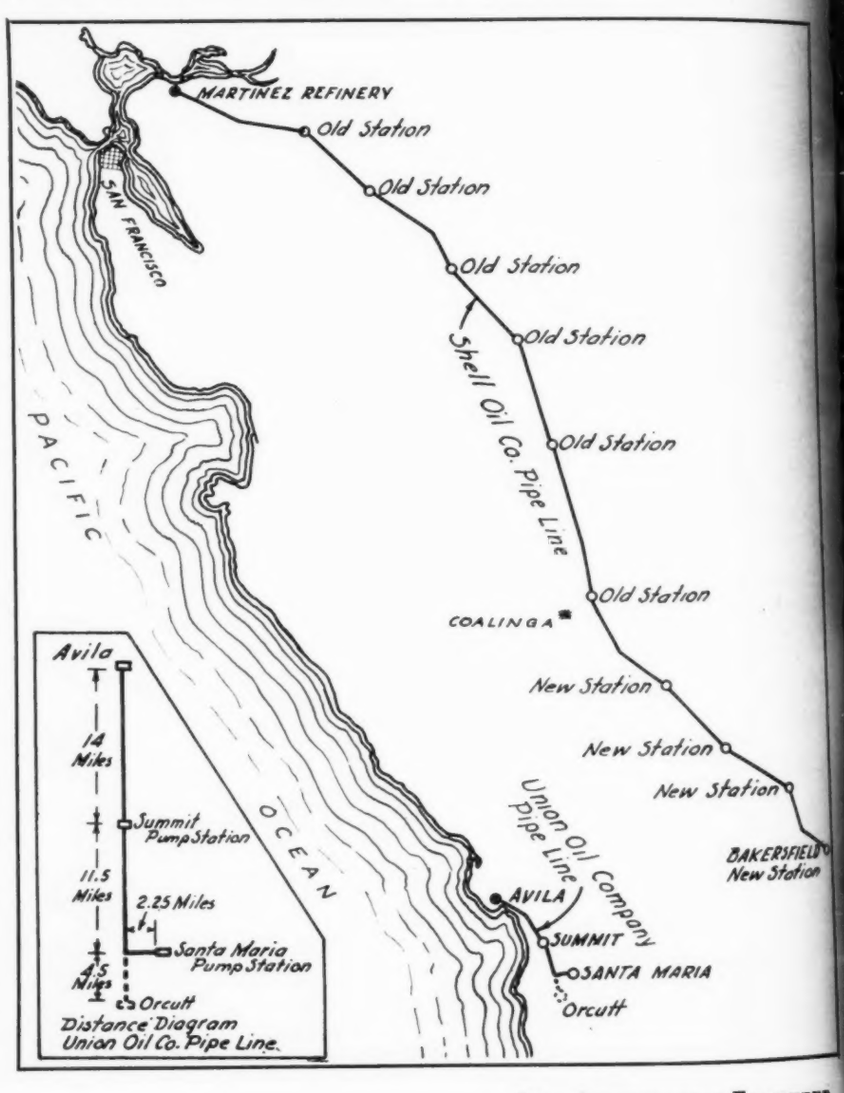

Fig. 1. Showing general location of stations on Union Oil Company and Shell Oil Company pipe lines

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Motor room of electric pump station on a gasoline pipe line

Electric Motors in Pipe Line Service

A discussion of the type of motors used in pipe-line pumping—their operation and characteristics

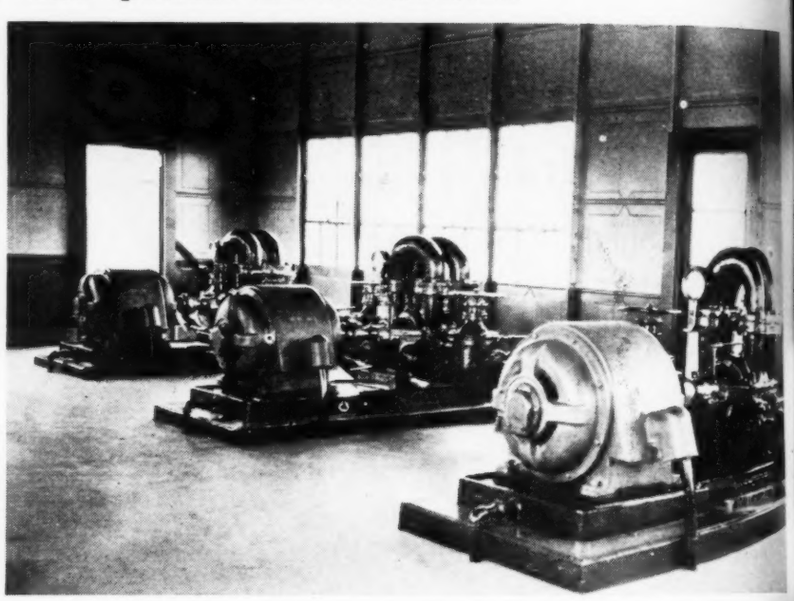
By G. R. PROUT[1]

ELECTRIC motors were used to a very limited extent by oil pipe line companies prior to 1926. At that time, however, centrifugal pumps of acceptable efficiency and suitable for handling crude oil under the volume and pressure conditions required by pipe line service appeared on the market. As the centrifugal pump is a high-speed machine, when handling large volumes at high pressures, it was quite natural that the development of the use of the oil-line centrifugal pump was carried on using the high-speed electric motor as the prime mover.

Electric motors for driving oil-line pumps now are considered fully established as standard drives by the pipe-line industry in the United States. The degree of acceptance is evidenced by the fact that there is now installed in pump stations of oil or gasoline pipe lines more than 250,000 hp. of electric motor capacity.

The power companies have transmission lines that cover much of the country through which oil and gasoline pipe lines pass, consequently reliable, economical electric service now is available or readily can be made so at almost any proposed location.

Centrifugal pumps for oil or gasoline pipe-line pumping service are high-speed machines, as was pointed out above. Almost all the present centrifugal pipe-line pumps operate at a speed of approximately 3550 revolutions per minute. These pumps are available with efficiencies from about 72 to 85 percent when handling crude oil in capacities from 20,000 bbl. to 75,000 bbl. daily at line pressures of 500 to 900 lb. per sq. inch. Smaller pumps also are available but their use in present practice is limited mostly to gathering-line service.



An early installation of motor-driven centrifugal pump station using one spare unit, at Bowie, Texas, installed in 1927. Capacity 30,000 bbl. per day at 550-lb. pressure

As these pumps operate at high speeds, the electric motor, which normally is a high-speed unit, combines readily with this type of pump to produce an inexpensive, light-weight, efficient pumping unit for pipe-line service. The ease of transportation and installation of such pumping units is of material advantage to pipe line companies, especially for booster pump station service, where speed of installation usually is important.

Types of Motors

Until the introduction of the gasoline pipe line, the constant-speed, squirrel-cage induction motor direct-coupled to the centrifugal pump, usually met the requirements of pipe-line pumping. Consequently most of the

[1]General Electric Company.

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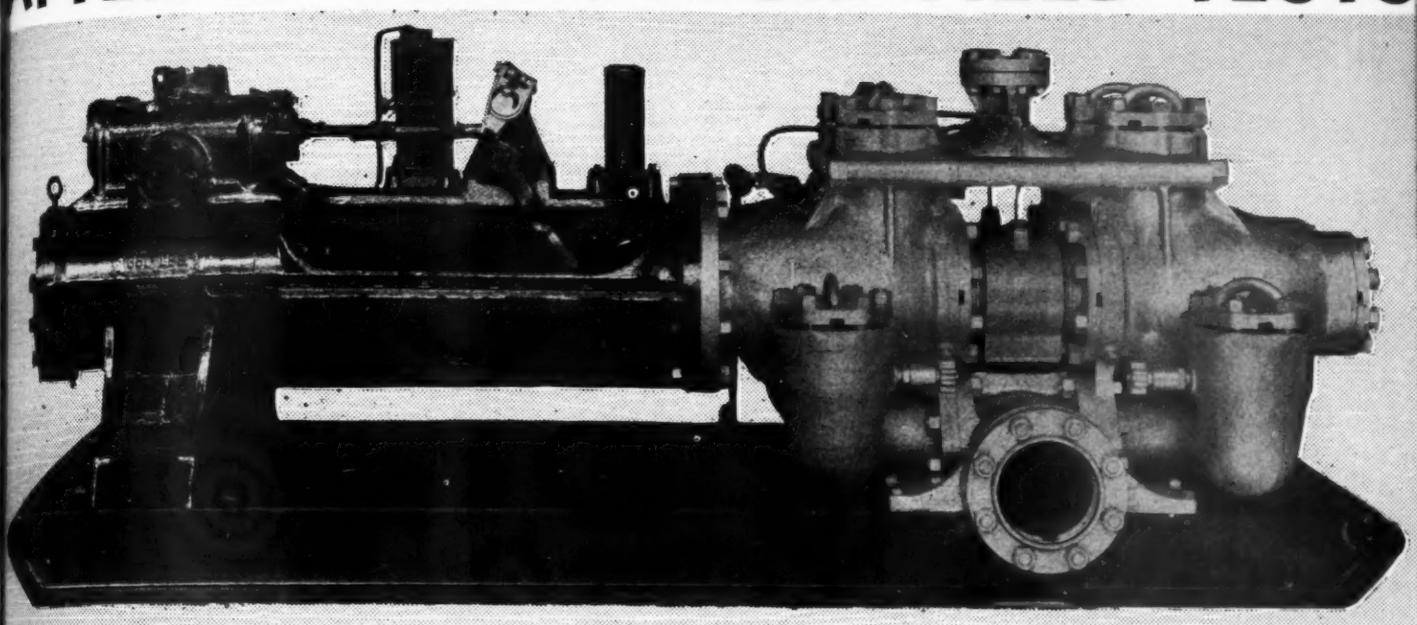

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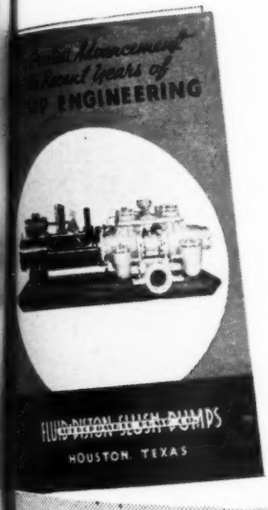

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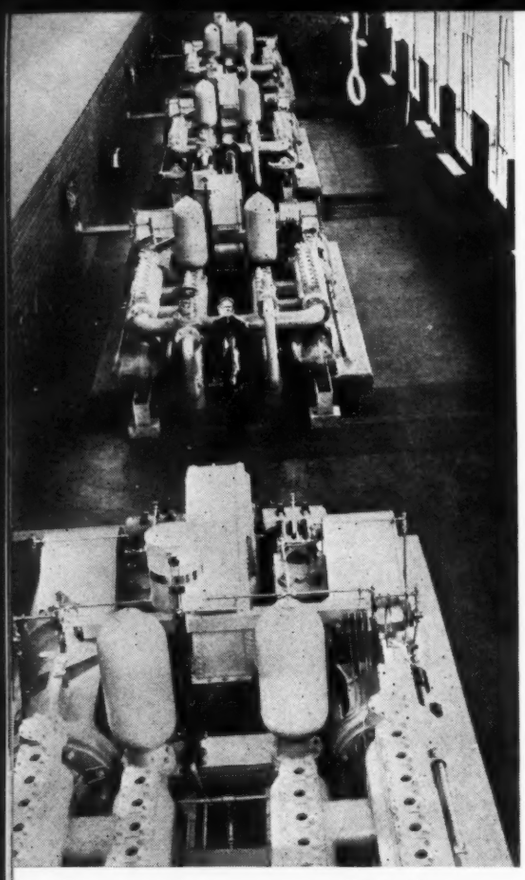


Pump room of motor-driven pump station on a gasoline pipe line

equipment now in operation is of the constant-speed type; however, variable-speed equipment is now being used to an appreciable extent on gasoline lines.

The squirrel-cage induction motor is the simplest type of electric motor. It has long, trouble-free life and operates with a very low maintenance and labor cost. The mechanical simplicity and sturdy construction of this type of motor, together with its relatively simple control equipment and its low first cost, make it the most popular type of motor with pipe line operators.

In some cases, particularly where power costs depend somewhat on the power-factor of the load, the synchronous motor with d-c. exciter is being used. This machine, while not quite so simple, mechanically, as the squirrel-cage motor, normally operates at unity or leading power factor and its efficiency usually is one or two points higher than that of the correspondingly rated squirrel-cage motor. Although these advantages are obtained at an increased first cost and somewhat less simplicity, the synchronous motor, where it has been used, has been highly satisfactory from the operating standpoint.

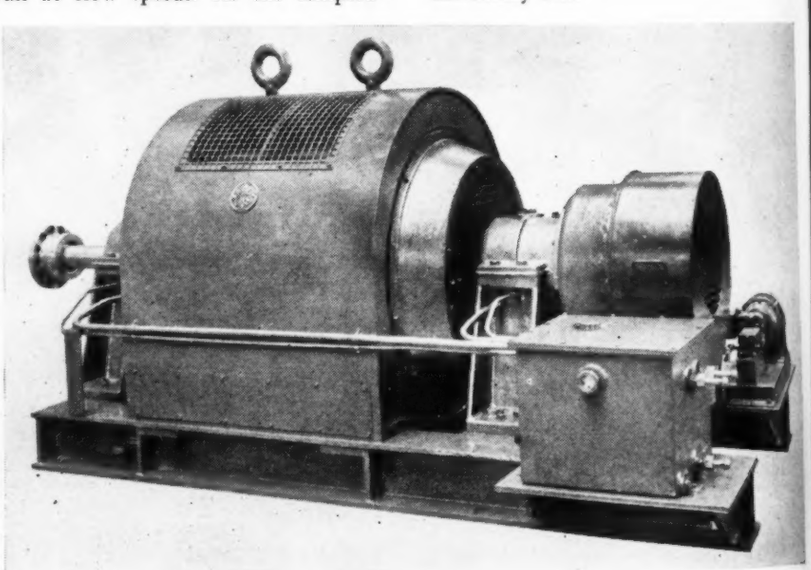
Slip-ring induction motors with variable-speed control have been used to drive reciprocating, as well as centrifugal, pumps where speed variation was required.

In some cases this type of drive has been used with centrifugal pumps to maintain constant, maximum allowable pressure on the line throughout the year. Ordinarily, the pressure maintained at the pump stations, on a crude-oil line using centrifugal pumps, drops during the spring as the temperature increases and the viscosity decreases. The minimum pressure is obtained during the summer months. During the fall, as temperatures again decrease and viscosities increase, the pressure increases until the maximum pressure results during the winter. Due to the fact that the head-capacity curve of the centrifugal pump is a drooping characteristic, i.e., as the pressure decreases the volume increases, the maximum pumpage is obtained on such a line during the summer months; however, if the pressure on the line under this condition could be maintained at maximum allowable instead of being permitted to decrease, the line would handle appreciably more oil.

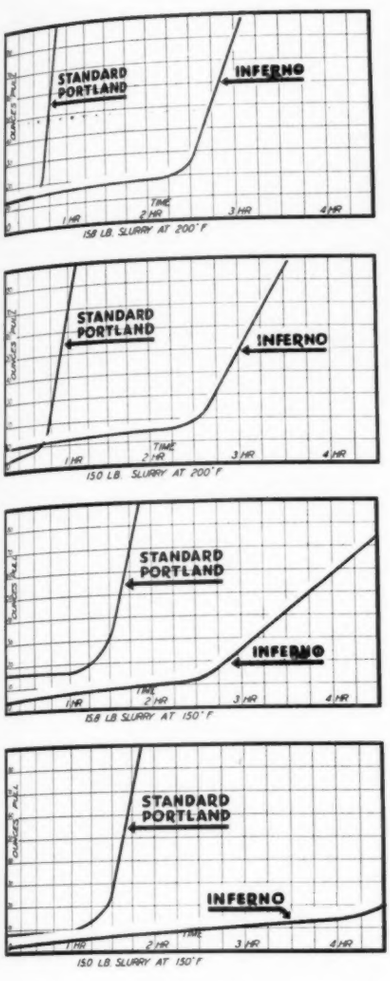
With this thought in mind several installations were made where the main pumps were driven by constant-speed squirrel-cage motors, and on the suction side of each station a full-capacity, low-pressure centrifugal pump, driven by a variable-speed slip-ring motor, was installed. This pump did not operate at all during the winter. Then as temperatures increased in the spring, these pumps were started and run at slow speeds. As the temperature increased further, as summer approached, the speed of these pumps was increased until full speed was reached during the summer. The reverse took place during the fall until winter arrived, at which time the auxiliary pumps were shut down. By this method of operation, constant maximum allowable pressure on the line was maintained and maximum annual pumpage obtained. The low-pressure, variable-speed unit supplied that required increment of pressure, which, when added to the pressure of the main pumps, gave that total station discharge pressure that was the maximum for safe operation. Of course, the fact that the pressure of a centrifugal pump varies with the square of the speed made this operating method practicable.

Variable-speed slip-ring motors driving reciprocating pumps also have been used to a considerable extent on gasoline pipe lines to provide a means for varying the volume pumped through the line.

The slip-ring motor when used with proper control equipment can operate over a wide speed range. The efficiency of the motor drops, however, as the speed is reduced, this drop being proportional to the reduction in speed if the torque developed is constant. Although this condition may be obtained when the motor is driving a reciprocating pump, in pipe line service, the volume pumped is decreased and the pressure required to pump the reduced volume usually is reduced so that the torque required falls also. Under these conditions, the motor efficiency drops a little more rapidly than the speed, but, as the actual power required also has decreased the motor efficiency is not quite so important as at full speed because the actual power developed is materially less.



A 600-hp. 3600-r.p.m. adjustable varying-speed slip-ring induction motor now used on a gasoline pipe line in Pennsylvania



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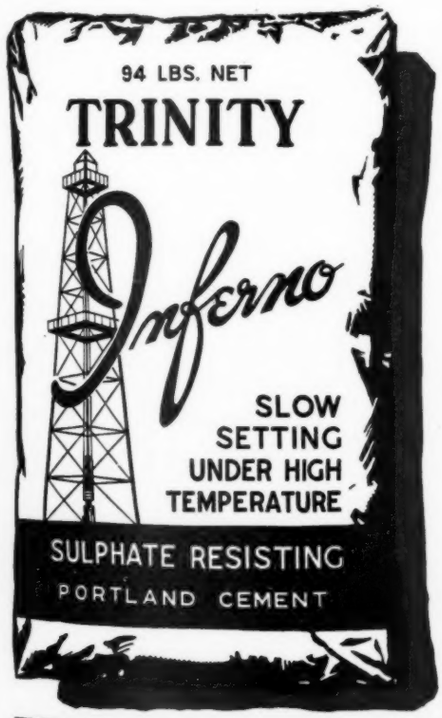

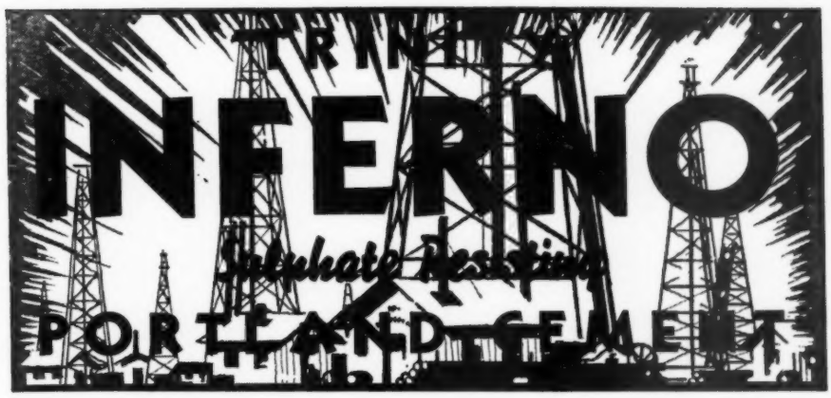

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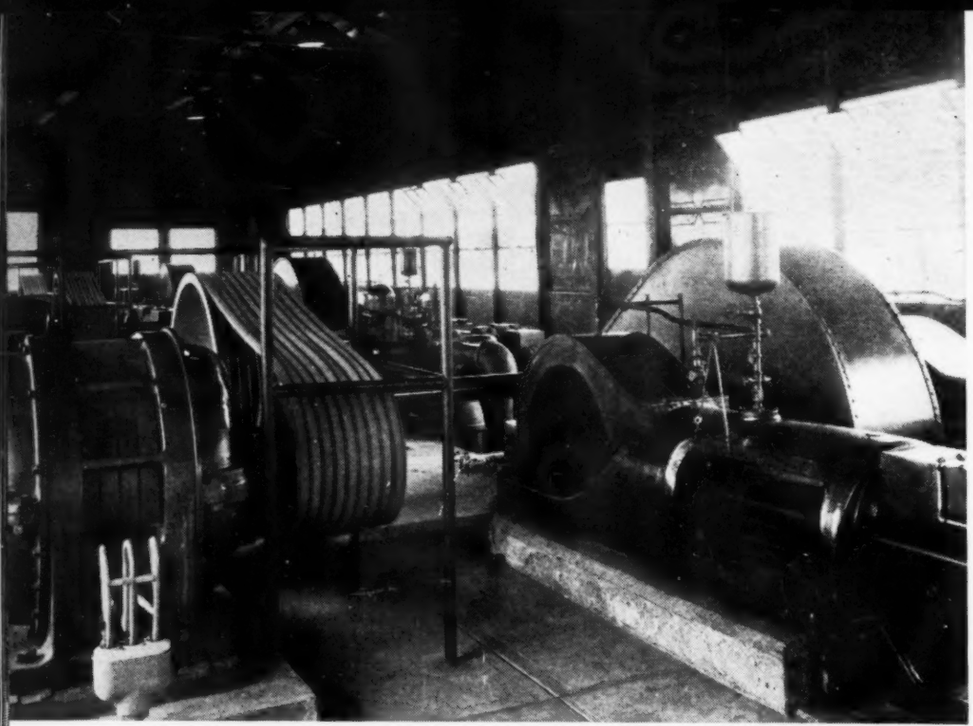
Cementing well in Rodessa field with "INFERNO" (Photo by LeDoux).



Electric motors driving reciprocating pumps in main-line station of a West Texas pipe line

The power required to drive a centrifugal pump varies as the cube of the speed; therefore, when a slip-ring-motor-driven centrifugal pump is operated at reduced speeds, the power drops off very rapidly. For example, if the speed is reduced 50 percent, the power required is reduced to about 12½ percent of that required at full speed; therefore, even though the efficiency of the motor drops more rapidly than the speed decreases, the actual losses in the motor are relatively small because the power required is so small.

Where pumping requirements vary widely from day to day, or season to season, as frequently happens on a gasoline line, the brush-shifting type of adjustable-speed a-c. motor has the advantage of permitting convenient, accurate speed-setting over a wide speed range without the larger loss of efficiency experienced with the slip-ring motor. The hp. and speed limitations of this type of motor, as well as its relatively high first cost, limits the possibilities of its extensive use in pipe-line service; nevertheless, there are certain applications where it fits into the economic situation well and undoubtedly it should be given consideration where variable-speed drive is required.

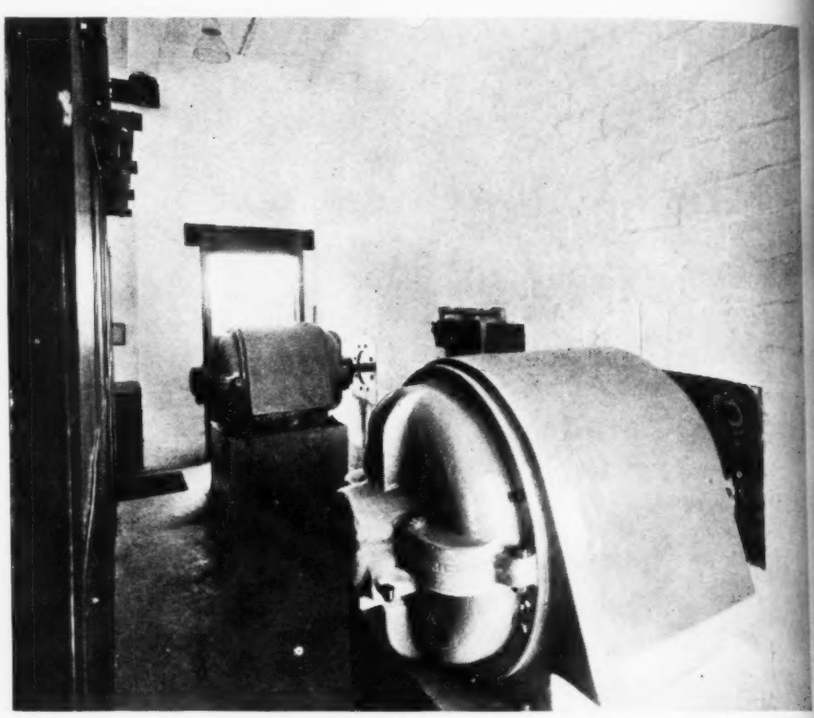
The brush-shifting type of motor, as well as the synchronous and slip-ring motors, require a fire-wall to be constructed between the motor and the pump for protection against ignition of gases by sparking at the motor brushes. Squirrel-cage motors have been installed in the pump room on crude-oil lines, without a fire-wall between the motors and the pumps, in a very large number of instances. So far as is known to the writer, there have been no fires in any pump station that could be traced to the motor or control equipment for their origin.

tions have been installed and the following advantages have been realized:

1. Low maintenance on the electrical equipment.

2. Flexibility in operation is afforded; that is, with a two-pump installation, either pump can be operated from either engine, either engine can be operated conveniently without load for adjustment, etc.

3. Electric power is readily available for driving station auxiliaries and lighting operators' cottages without investment in additional generating equipment.



Two 350-hp. 3600-r.p.m. 2200-volt squirrel-cage motors driving pipe line centrifugal pumps through firewall; 42,000-bbl. per day capacity

Engine-Generator-Motor-Driven Pipe Line Pumps

Occasionally a proposed pipe-line station location is such that a large expenditure is necessary to serve this station with central station power. When such a problem arises, the Diesel engine is of course immediately considered. It can be used with speed-increasing gears and centrifugal pumps, but certain definite advantages are obtained by the use of Diesel engines and electric generators with motor-driven centrifugal pumps. Several such sta-

4. If increased pumpage at a station requires the original pumps to be replaced with larger pumps at some later date, the original engines and generators can still be used by adding one more engine-generator set of suitable capacity.

5. When requirements for pumping are such that a station can be eliminated, the engine-generator sets can be readily moved to another station or to a producing property where electric motors may be used.

6. The speed of the pumps can be

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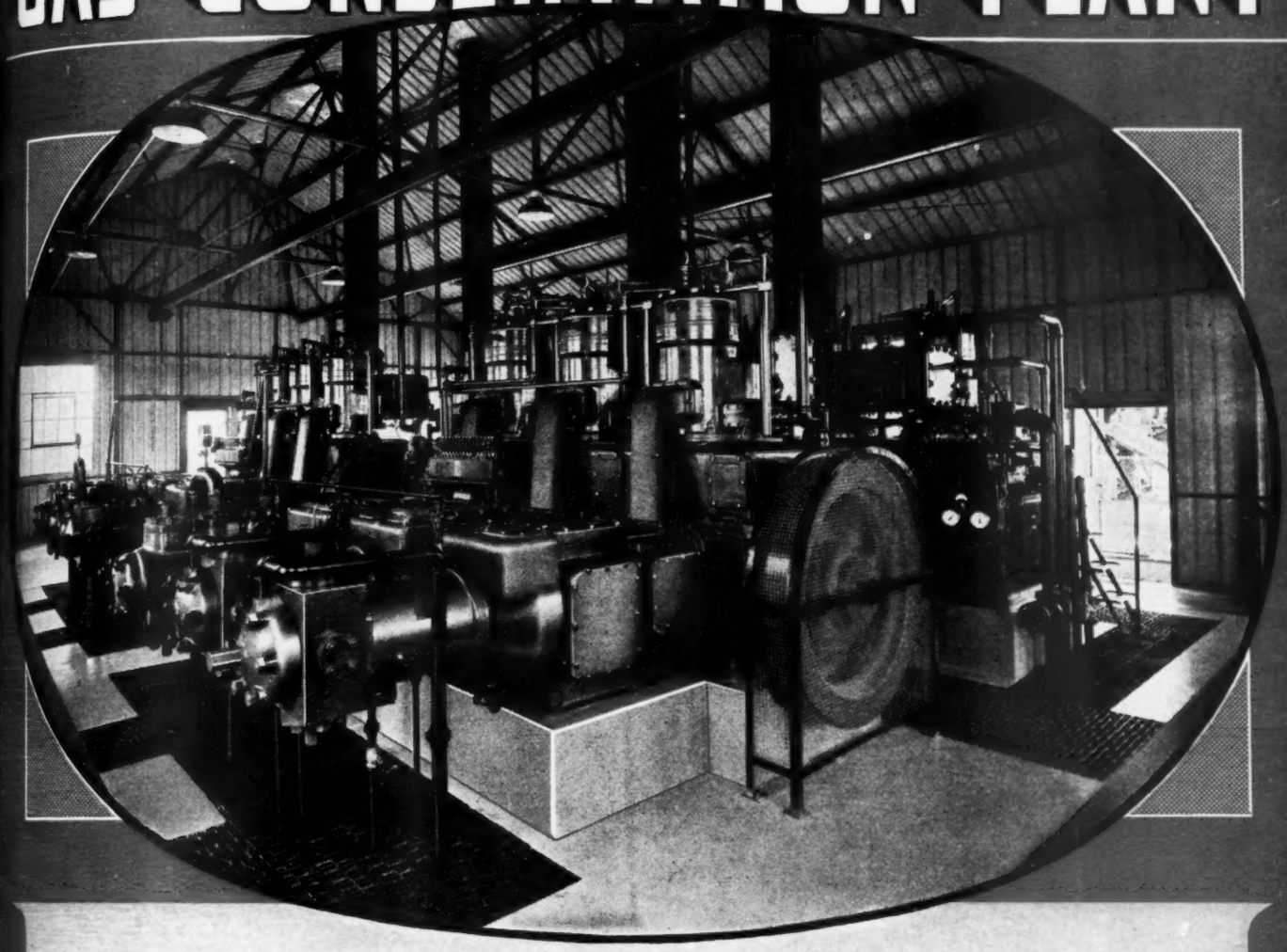

This pressure maintenance plant of the Continental Oil Company, at Tepetate, Louisiana, contains 4 CLARK 300-H.P. "Super-2-Angle" Compressors delivering 2,000,000 cu. ft. of gas a day each, from 350 pounds suction pressure, 3,600 pounds discharge pressure. Units have been operated at maximum pressure of 4,600 pounds.

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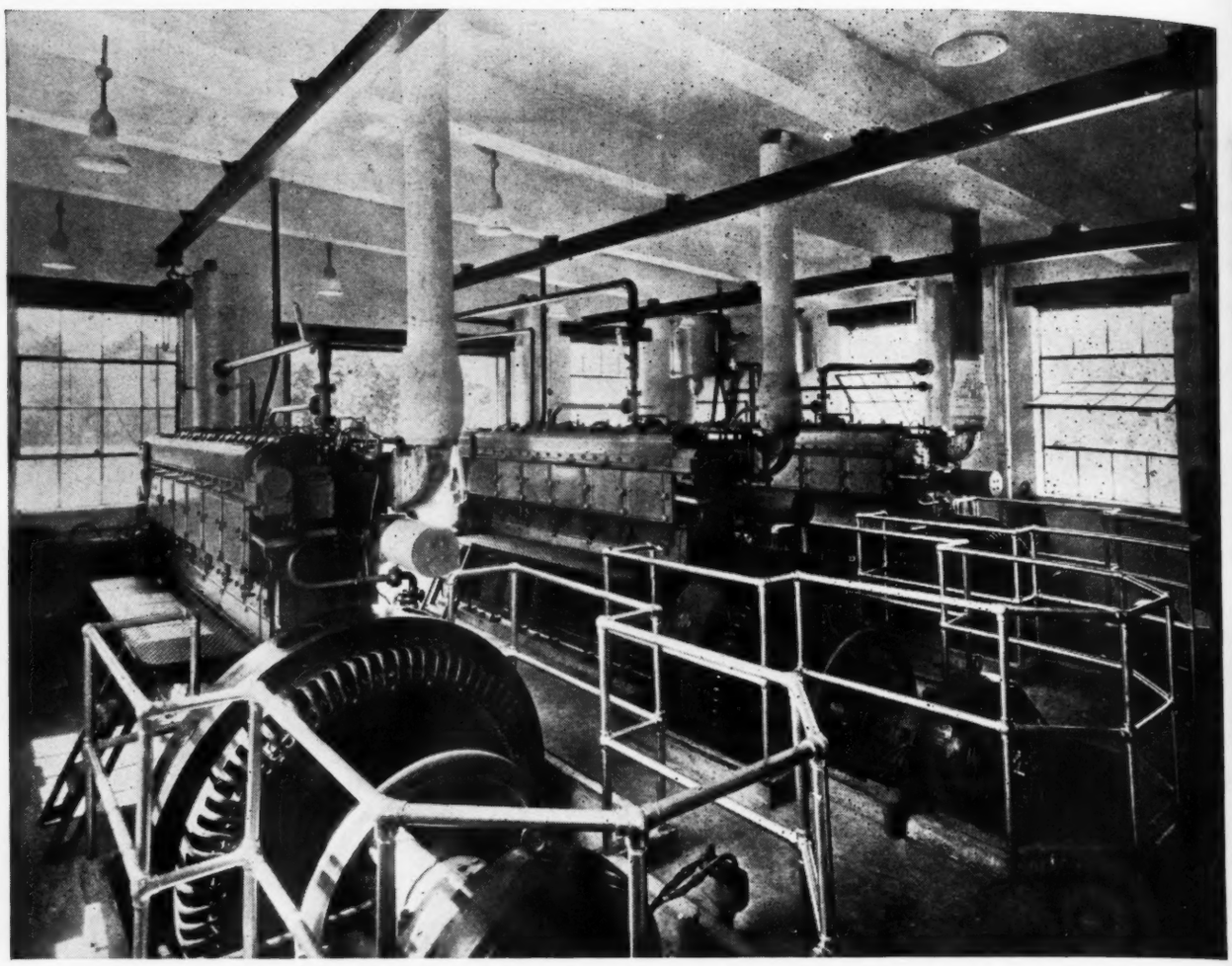

Diesel engine generating room of a pipe line station with 42,000-bbl. daily capacity, using two 350-hp. motor-driven centrifugal pumps

changed readily, merely by changing the speed of the engines.

7. Complete tests of station operation can be made easily by the use of electrical instruments. This allows the fuel and lubricating oil consumption of engines to be accurately checked against energy generated and also provides a convenient accurate means for checking pump efficiencies. Therefore, the causes of excessive fuel and lube consumption can be found quickly and corrected with resulting saving in operating cost.

8. By means of a watthour meter on each generator panel, the exact amount of energy put out by each engine can be determined easily for any given period of time. This is of material help in arranging operating schedules.

9. If one engine is installed to drive two pumps, it is not necessary to run both pumps at all times or to uncouple one pump in order to run the other. Either pump can be operated at will with resulting convenience and saving in operating costs.

10. The total cost of the completely installed station compares favorably with the engine-gear type of station.

11. High-speed efficient pumps can be used without increased first cost or increased maintenance cost.

12. Slow-speed engines can be used without encountering any difficulty with respect to speed-increasing ratio.

13. Any number of engine-generators can be used to supply energy to two pumps. This means that several relatively small engines in the stock of a pipe-line company can be used with generators to drive two large motor-driven centrifugal pumps.

14. Equipment is simple to operate.

15. Motor-driven pumps in this type of station may be used later at some other station location with purchased power.

16. Motor-driven pumps in existing stations can be used with engine generators.

Stations using engine and generators with motor-driven centrifugal pumps have been in operation almost constantly for nearly five years. The operation of these stations has been economical and highly satisfactory.

Pipe-line operators now are thoroughly aware of the advantages afforded by the use of motor-driven centrifugal pumps with purchased power. Power companies and electrical manufacturers, as well as the pump builders, appreciate the problems of pumping oil and gasoline in pipe lines and consequently are able to coöperate with the pipe-line operators to a much greater extent in the solution of these problems.

Where purchased power is not available, engine generators still permit the use of motor-driven centrifugal pumps and provide many advantages that have proved important in actual operation over a considerable period of time.

With the foregoing in mind it seems evident that the pipe line industry should use electrical service and electrical equipment for pumping oil and gasoline to an even greater extent in the future.

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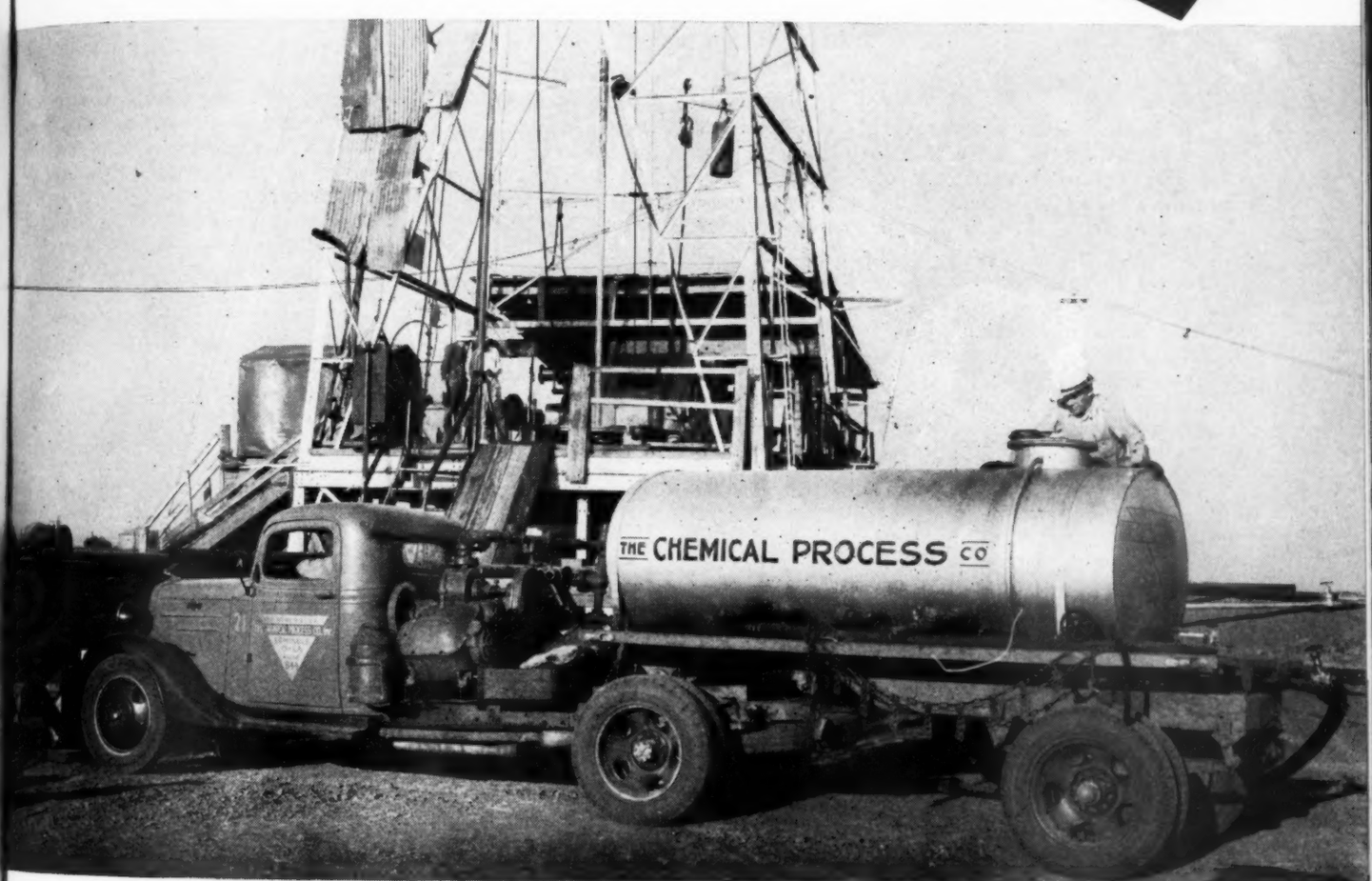

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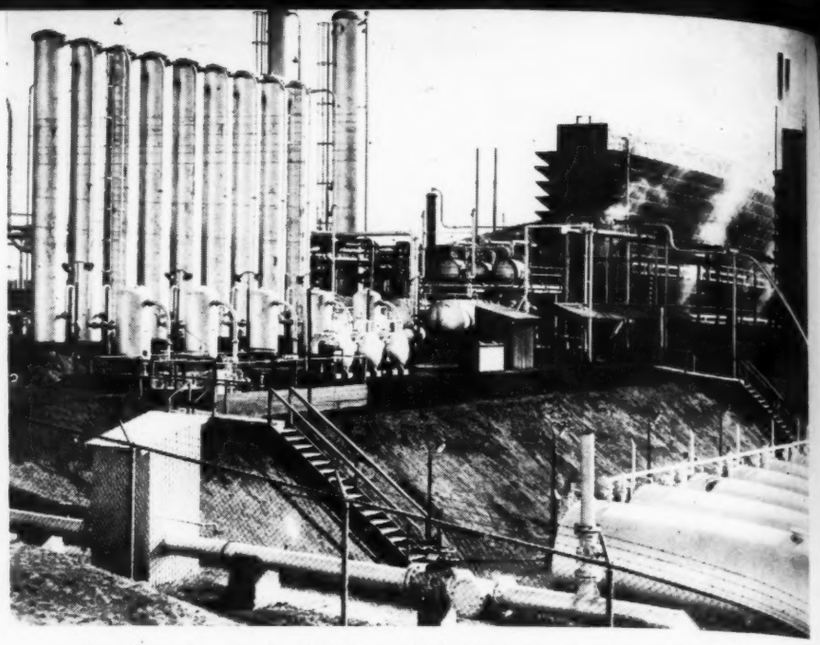


Gasoline plant in the Kettleman Hills field, North Dome, California

A Review of Progress and Trends in

By K. C. SCLATER

LEAN years during which overproduction was rife and the economic structure of the industry shaky, have had a salutary effect on the producer. Lessons learned then have not been forgotten. The producing branch of the industry has awakened to the folly of many of the practices it blindly followed. Today these rapidly are being corrected and already the benefits are beginning to be reaped. Proration of production as between states, fields, and wells, now is universally accepted and practiced. Not satisfied with the progress that already has been made, further efforts are being directed to improve proration methods. A survey of production activities during the past year discloses that a vast amount of research work is being carried on to this end.

The industry seems to have settled down to the task of attacking problems that are fundamental in character and the solutions of which are likely to be far-reaching in their influence on future production practice.

Among such problems that are having particular attention are those involving subsurface conditions in the reservoir as they apply to the economical production of oil and gas. They cover subsurface pressure measurements and equipment; sub-surface sampling of oil and its examination; the energy characteristics of the reservoir contents; the determination of connate-water content of oil sands; and improving the technique involved in examining cores, particularly with reference to providing accurate information for use in secondary recovery projects, including pressure maintenance, repressuring, and water-flooding.

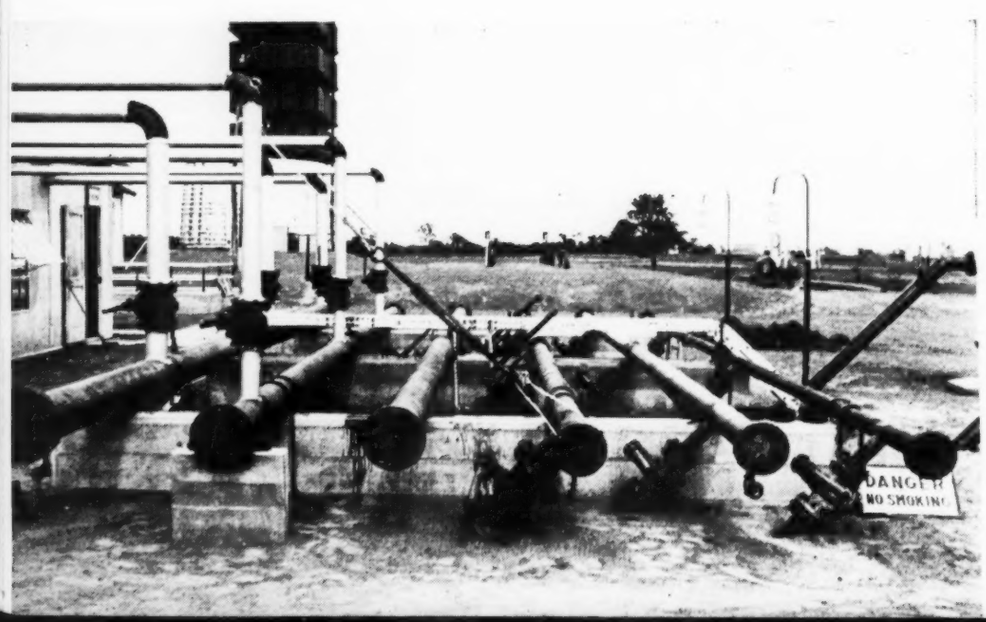
SUBSURFACE STUDIES

Bottom-hole pressure measurements are now widely used, particularly for following the depletion of reservoir energy. Bottom-hole pressure readings in most flush and semi-flush fields are taken at regular intervals, and the pressure drop compared with the production. From this decline in reservoir energy not only can estimates be made regarding future production, but it indicates the efficiency of operations, and what is important to the operator, it enables him to estimate in advance equipment requirements for pumping his wells. Even individual well behaviour can be studied from accurate bottom-hole pressures obtained while the well is producing. Accurate subsurface measurements are therefore very desirable.

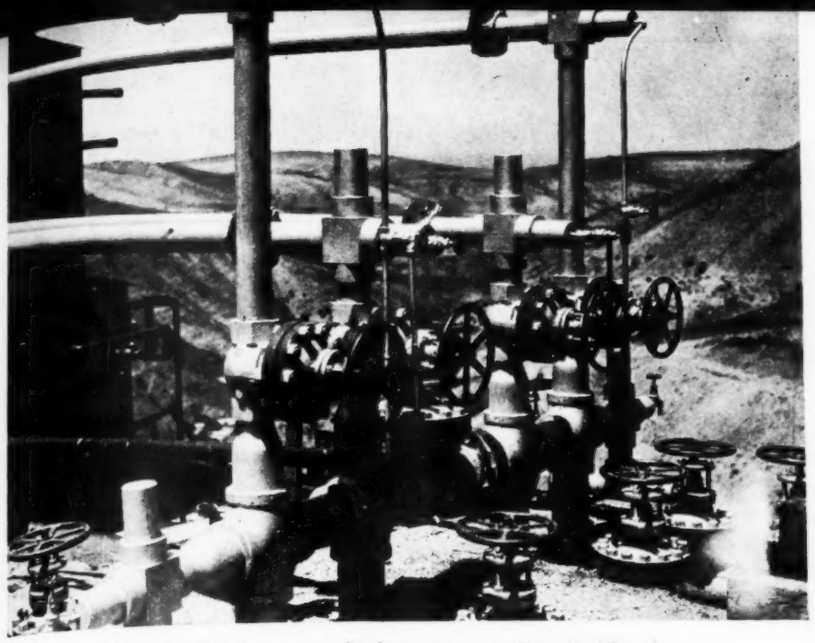
A new precision gauge for subsurface pressure measurements capable of measuring bottom-hole pressure with great accuracy recently has been developed.[1] It uses bellows as the primary pressure element and, it is said, should detect the pressure difference due to approximately four ft. of fluid. The gauge obtains a record on a metal chart, which is measured under a special microscope to ensure accuracy. The development of this instrument is indicative of the improvements being attempted to obtain greater accuracy in bottom-hole measurements.

Closely related to bottom-hole pressure is that of the nature of the fluid at the bottom of the hole. What are its physical properties? This information is important to the producer to guide him in determining how the well should be produced. What means are available of taking a sample at the bottom of the hole so that it can be examined at the surface and its condition and characteristics as it exists at the bottom of the hole determined? For this purpose an improved sampler and also apparatus for examining the sample under controlled conditions have been developed. In a recent paper[2], in which the sampler and apparatus are described in detail, the author states that, "The equipment is capable of being set up in a field laboratory, making it possible to obtain and examine a large number of samples in a relatively short time. Although use of this equipment has shown that reliable results may be obtained in a minimum of time, further experiments with the sampling technique and certain additions to the apparatus to increase its flexibility are desirable."

Further work has been done on the investigation of the fluid contents in



Manifold on a modern high-pressure compressor station in the Fitts Pool, Oklahoma



Flow-line hook-up on a high-pressure well in California

in Production Practice

the reservoir with regard to their volume and energy characteristics. Under the extremely high pressures found in deep fields such as Kettleman Hills and others that have high gas/oil ratios, the investigations made thus far indicate that gas behaves more like a liquid, having almost the physical properties of a liquid. As Lacey[3] points out, you cannot tell by seeing a sample of gas, or a sample of liquid, which you have. In the critical region, with high pressures and high temperatures, the difference between gas and liquid is purely a question of definition.

The results of these investigations, despite the complicated and highly technical nature of the subject, have a very practical value. A knowledge of the nature and behaviour of the reservoir fluids as they exist in deep fields is essential in producing oil efficiently. Drilling to depths greater than 10,000 ft. and producing oil and gas therefrom will demand a more thorough knowledge and understanding of this subject if the most efficient utilization of reservoir energy is to be attained.

Investigations on the connate-water content of oil sands have opened the eyes of the industry to the importance of this subject with respect to the problem of calculating reserves by volumetric methods. It is only in the last few years that the connate-water content of oil sands has come in for any consideration. This is surprising in view of the fact that field studies indicate that appreciable quantities of connate-water are present in the pore spaces of the average oil sand. Tests made at one well showed that an average of 38 percent of the effective pore space of the oil sand was occupied by connate water[4]. Tests made by other investigators indicate that connate water probably is present in oil sands in percentages greater than was generally believed. In the paper just cited[4] the authors describe an improved method of determining the content of connate water in an oil sand. This is further evidence of the intensive subsurface studies that are being carried on in the investigation of reservoirs. The practical application of the results of these studies is obvious.

Methods of mechanical coring and making core analyses constantly are undergoing improvement and are becoming increasingly greater aids in the practical phases of producing oil.

FLOWING WELLS

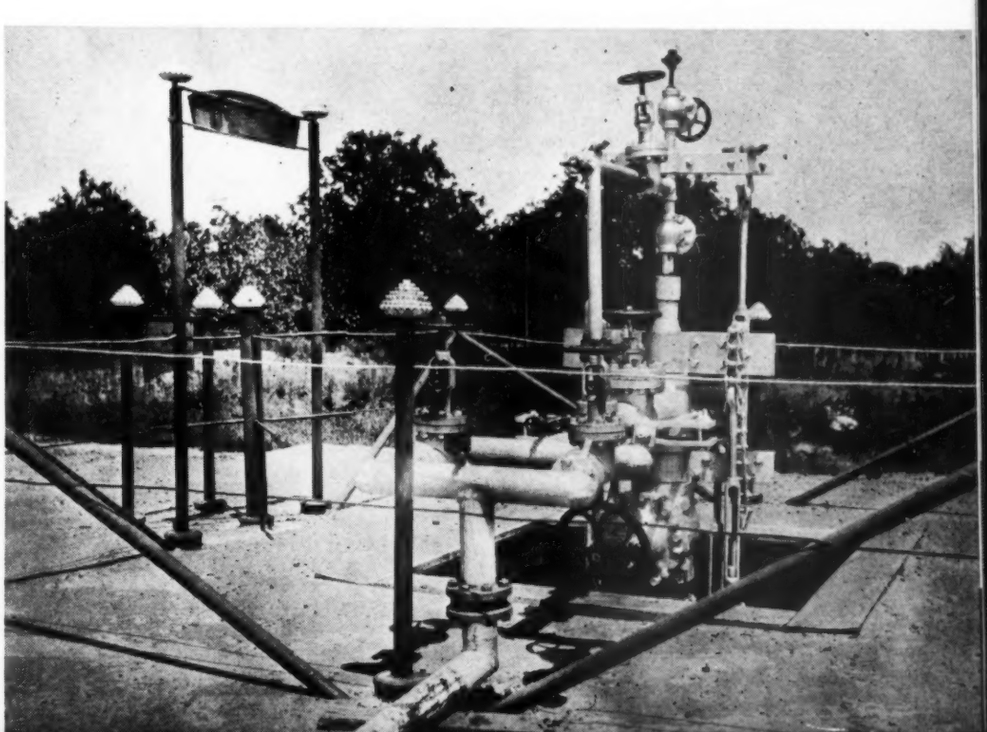
How the flowing life of wells can be prolonged always has been an intriguing problem. Recent field investigations on this subject[5] show that, "the gas/oil ratio has a greater effect on pressure differences in the tubing than does the tubing size or rate of flow." It is believed that the ratio of free gas to amount of gas in solution also is an important factor. From the results of their field tests Kemler and Poole[5] conclude that, "The pressure drop in the tubing is not caused entirely by friction as might be supposed, but is a combination of the effect due to friction and the difference in pressure due to fluid head. The difference in pressure is due mostly to the actual pressure head and it is for this reason that the gas/oil ratio exerts an important effect through the aeration of the column and consequent changes in the static head.

"The effect of tubing size, except for very large or small rates of flow, will tend to cancel out; as the pipe size is increased, the friction decreases, but the slippage increases, so that the net change is unimportant as compared with other factors."

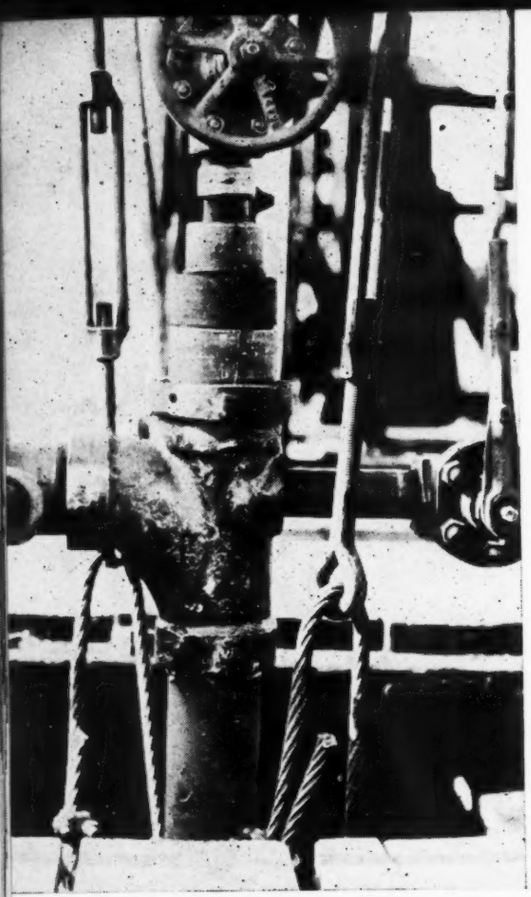
These tests were made on some 34 wells in West Texas.

PUMPING WELLS

The increasing depth of wells adds to the difficulties of pumping by mechanical means, such as beam-pumping. Crooked holes also increase the difficulties of pumping deep wells, but in what degree is not known. With the introduction and increasing use of directional drilling, the question of pumping directional-drilled wells economically looms as a problem. An example of the problems to be overcome is described by Weaver[7]. The wells pumped have an approximate average depth of 4300 ft. and the angle of inclination for the group varies from 15 deg. to 62 deg. from the vertical. Despite the high angle of inclination, the production costs are not excessive, although it is predicted that the eco-



Modern hook-up on gas well near Cushing, Oklahoma



Compact hook-up on a small producing oilwell in the Mid-Continent

nomic life of such wells will be shorter than that of vertical wells.

Another interesting study in connection with the pumping of wells is that of vibration. It is found that vibration has a profound effect upon the shape of dynamometer cards taken on a pumping well. Vibration thus enters into the problem of oil-well pumping. A simplified method of calculating vibration frequencies as applied to sucker rods has been worked out[8] that will aid in diagnosing oil-well pumping troubles from dynamometer cards.

DETERMINING FLUID LEVELS

A means of determining fluid levels in producing wells recently has been perfected.[9] Essentially, it consists of releasing compressed gas into the casing and setting up a pressure wave, which travels down the well and back again, and obtaining a record of the wave's release and return. From this record the fluid level in the well is determined.

A diaphragm receives the pressure wave, and other apparatus, included in which is a mirror for reflecting a light beam, makes a photographic record of the pressure wave as it is received by the diaphragm.

This device may have a number of applications in the solution of oil well pumping problems.

A knowledge of the fluid level in a producing well has been difficult to determine with any degree of accuracy. When a well is producing the fluid level will vary with the pressure in the top of tubing or the casing. Because of the presence of gas in solution in the oil it is not always possible even to calculate what the fluid level is. A positive means of determining the fluid level such as this device provides should aid in improving well production practice.

WATER-FLOODING

Water-flooding in the Mid-Continent during the past year has continued to gain in interest. It has been found that its application there, despite the progress made in the Bradford field, Pennsylvania, is somewhat of a pioneering venture. This has arisen not so much from the difference, compared with Bradford, in underground conditions but principally from lack of an adequate source of supply of suitable water. Economically, this probably is the greatest stumbling block to the success of water-flooding in Northeastern Oklahoma. Water-conditioning is necessary if corrosion of equipment and clogging of the sand are to be avoided. Essentially the same fundamental principles of water-flooding apply wherever water-flooding is practiced. It is the local conditions encountered that necessitate different methods of attack and give rise to new problems.

The Forest Oil Company, on a 160-acre tract near Nowata, Oklahoma, in the first ten months by water-flooding produced 679,342 bbl., an average of 4,245 bbl./acre. The ultimate recovery on this tract, as estimated by the Forest Oil Company, is 5000 bbl./acre.[6]

The results obtained on this 160-acre tract represent good practice and are indicative of what can be accomplished when experience and sound methods are applied.

PRESSURE MAINTENANCE

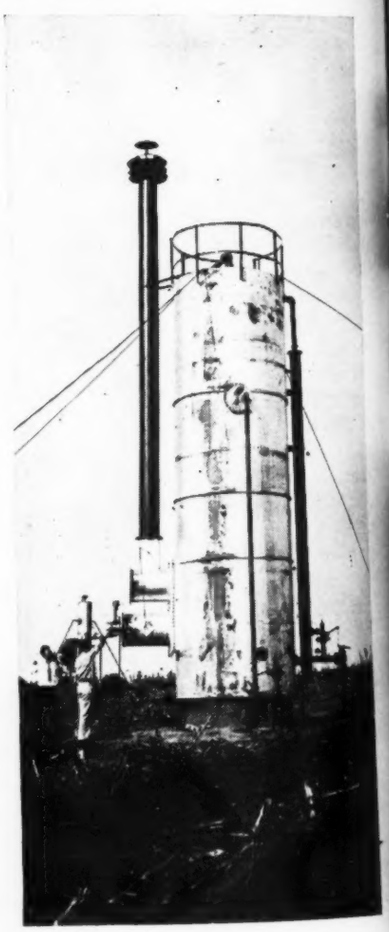
Progress in pressure maintenance methods is seen in the results being obtained in at least two major projects recently begun on which information has been made available. One of these is the pressure maintenance and unitization project in the South Burbank Pool.[10]

Some 2720 acres of approximately 4000 productive acres have been unitized. It is expected to prolong the flowing life of wells by returning gas to the sand and thus increase the ultimate recovery of oil; and to effect economies in development. For every barrel of oil produced approximately 1640 cu. ft. of gas is returned to the sand in the unitized area. Operators outside the unitized area are returning an average of 414 cu. ft. of gas per bbl. of oil produced.

Pronounced changes in gas/oil ratio have occurred despite the fact that the rate of oil production monthly has been fairly uniform for twelve months. Observed increases in gas/oil ratios are believed to be the result of the gas cap spreading from injection wells through permeable channels. In this connection the observation is made that: "It is significant, however, that notwithstanding the large gas withdrawals coincident with mounting gas/oil ratios, the reservoir-pressure drop, in lb./million bbl. crude produced, has decreased in corresponding time; thus the drop for the period ending in May was 31 lb./million bbl; from May to August it was 30 lb./million bbl.; and in the following three months only 19 lb./million bbl. of oil produced. The reverse in drop is partly satisfied by increased deliveries of gas back to the reservoir. There are possibly other factors that are ancillary to this occurrence which at present are not clear enough to be stated with a certainty."

It has been found necessary to com-

A pressure treater for treating oil under pressure in use in a field in Oklahoma



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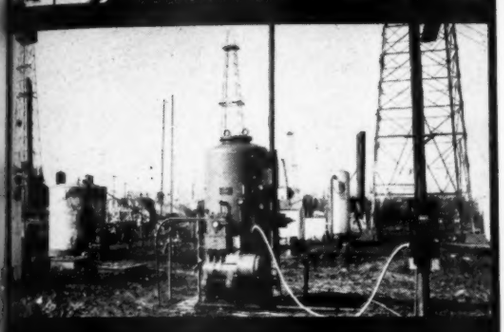

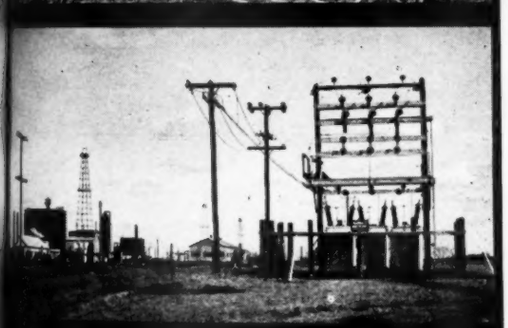

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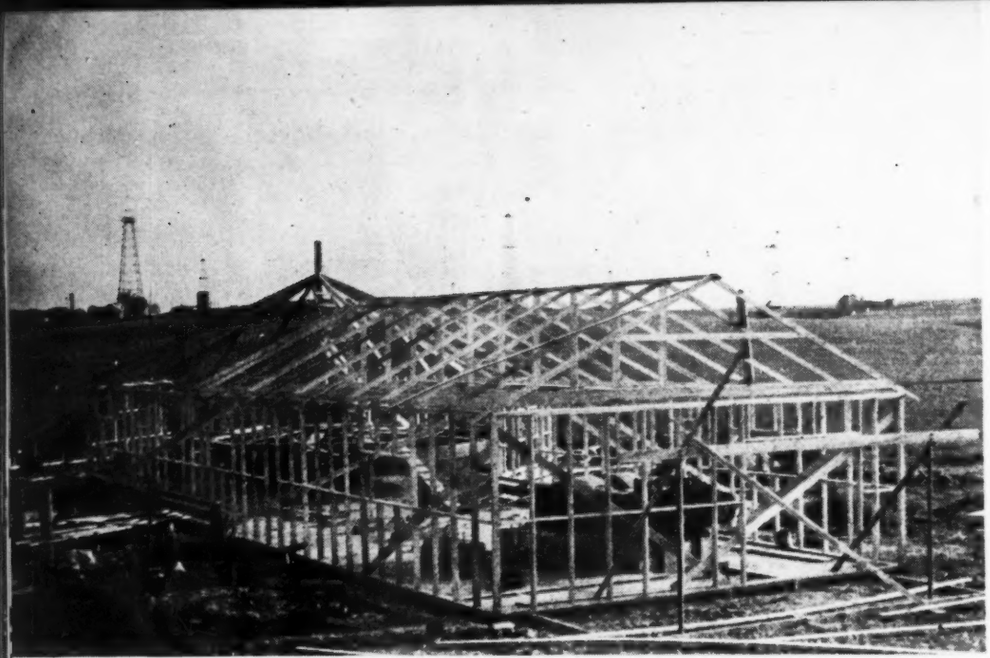

Modern central power plant under construction

The modern central power plant shown above completed

bat high gas/oil ratios. Packers have been set in wells to separate an upper gas-bearing zone in the same sand reservoir. They are proving effective in reducing gas/oil ratios.

Another interesting pressure maintenance project is that recently begun in the Tepetate field, Southern Louisiana. This field has been developed under the most modern methods. All crude production is stabilized at the well, the lighter ends of the oil and the heavy constituents of the gas being removed.[11, 12] The average depth of the wells in this field is approximately 8300 ft. and a spacing of one well to 20 acres obtains in the field. An effort will be made to prolong to the utmost the flowing life of the wells in this field, so it is planned to return all dry gas produced with the oil to the sand with the exception of a small amount that is being sold for industrial uses.

One feature of this pressure maintenance project is the high-injection pressure used to return the gas to the sand. The absorber and crude stabilization units were designed for operation in conjunction with the pressure maintenance system to provide residue gas at a pressure up to 500 pounds. As presently operated the pressure maintenance plant receives gas to the compressors at approximately 350-lb. pressure. It is planned to increase this pressure as soon as additional input wells are completed.

This pressure maintenance project in conjunction with crude stabilization plant is an innovation in production practice. Even the compressors are of a new type with vertical power cylinders and high-pressure compressor cylinders. Each unit has a capacity of 300 hp. operating at 300 revolutions per minute. Each unit has one low-pressure and two high-pressure cylinders, the latter being outside packed with metallic rings riding directly on the plungers.

Normal injection pressures in use are between 3500 and 3750 lb. per sq. inch. This is believed to be the highest working pressure ever used for returning gas to producing formations for oil recovery purposes.[12] "Under this condition a cu. ft. of gas weighs approximately 16 lb., or about one-fourth that of water, and velocities are low. When handling 7,000,000 cu. ft. a day at 3500 lb. per sq. in. in a line with an inside diameter of 3.286 in., the velocity is about 6.5 ft. per second.

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Construction scene on an oil pipe line in southeastern New Mexico

Progress in Electric Welding of Pipe Lines

An interesting development during the past year was the increased use of the "stove-pipe" method

By
A. F. DAVIS[1]

PROBABLY the most interesting development in the construction of pipe lines by electric-welding during 1936 was the increased use of the "stove-pipe" method. "Stove-piping" was employed more extensively during 1936 than in any previous year. The method originally was developed for electric-welded construction of pipe lines through rough or muddy terrain where it was difficult to complete more than a mile of line a day. The method was found effective under such conditions inasmuch as it does not require the use of a line-up crew. As the line-up crew works to greatest advantage under conditions where the pipe can be lined up readily for welding, its expense is hardly justified when the work is delayed due to mud or other obstacles. With the "stove-pipe" method, all pipe welds are made individually in much the same manner as bell-hole welds are made in the ordinary "firing line" method of pipe-line construction. The "stove-piping" crew, consisting of the regular welding crew plus one or two additional welding operators, performs the work of lining up the pipe and also arc-welding the joints. This is different from regular "firing line" procedure in which one crew lines up the pipe and another crew follows making the joint welds.

Scene on an 8-in. gasoline line laid for the Atlantic Pipe Line Company from Harrisburg to Pittsburgh, Pennsylvania

Ordinary procedure in the "stove-pipe" method of constructing pipe lines by electric-welding is to line up the pipe on skids high enough above the ground to permit making the welds entirely around the joint. Each joint is welded individually with the pipe stationary. The joint is tack-welded as the pipe is lined up, following which the joint-welding is finished. The speed of connecting the pipe depends upon the speed at which the lining-up is accomplished.

The economy of "stove-piping," where the method can be employed to advantage, can be appreciated. The cost of the line-up crew, averaging from $60 and $80 per day, is saved. Instead of having the entire crew spread out over several miles of the right-of-way, it is bunched.

In welding pipe joints by the "stove-

[1]Vice-President, The Lincoln Electric Company, Cleveland, Ohio.

Pipe welds made by electric arc process for Columbia Gas System

pipe" method, three beads are used per joint. The pipe is lined up with a space approximately ⅛ in. between the pipe ends. No backing-up ring is used. Table 1 gives electrode sizes for welding the three beads in various sizes of pipes:

TABLE 1

Size Electrodes Used for Welding Three Beads by "Stove-Pipe" Method

Dia. of Pipe	Electrode Size First Bead	Electrode Size Second Bead	Electrode Size Third Bead
6 in.	5/32 in. - 3/16 in.	3/16 in.	3/16 in.
8 in.	7/32 in. - 3/16 in.	3/16 in.	3/16 in.
10 in.	3/16 in.	3/16 in.	3/16 in.
12 in.	3/16 in.	3/16 in.	3/16 in.

TABLE 2

Comparative Pipe Welding Speeds—"Stove-Pipe" and "Firing-Line" Methods

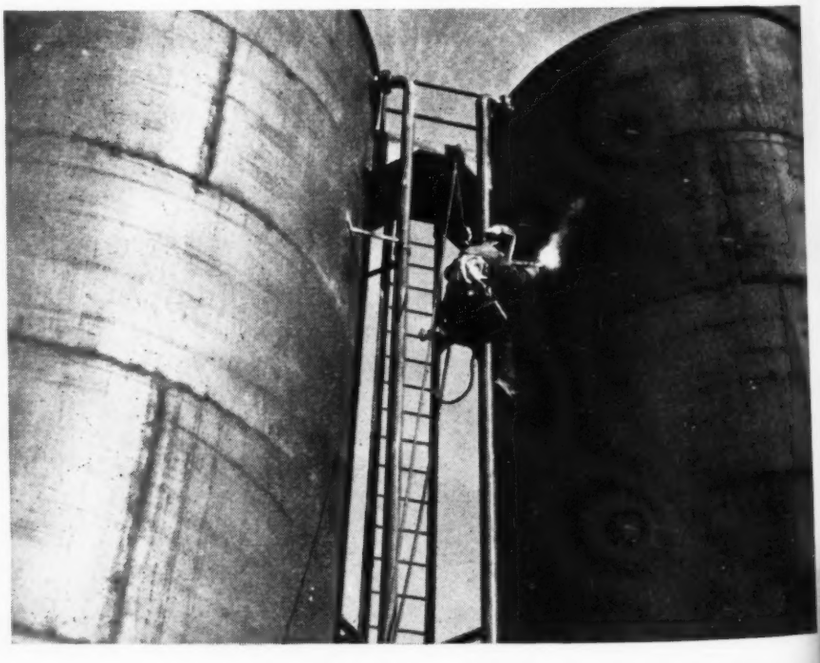
Dia. of Pipe	Average Weld per hour "Stove-Pipe" Method	Average Weld per hour "Firing-Line" Method
6 in.	3.0	5.0
8 in.	2.5	4.0
10 in.	2.0	4.5
12 in.	1.5	3.0

Data taken from records of 688,126 jobs in 5470 lines.

The value of the "stove-pipe" method of electric-welding pipe lines cannot be appraised on any basis of speed compared with the "firing line" method. The real economy of "stove-piping" lies in the fact that it substitutes for "firing-line" welding, which cannot be used under extremely adverse conditions or employed to greatest advantage on short lines, a method that permits obtaining best results under the circumstances. Pipe joints are welded by the "stove-pipe" method at approximately half the speed at which they are welded on the "firing line." Table 2 gives the speed at which pipe joints without backing-up ring are welded in various sizes of pipes both by the "stove-pipe" and the "firing-line" methods.

Although the use of the "stove-pipe" method of electric-welding pipe lines increased considerably during 1936, of course, it will never replace the "firing-line" method for the construction of lines of any length where the utmost speed of welding is required. Every year a great increase is shown in the speed of connecting pipe by electric-welding with the "firing-line" method. The latest record-breaking speed was made in construction of the new 304-mile 10-in. crude oil pipe line laid by electric-welding for the Shell Oil Company from Bakersfield to Martinez, California. This line was completed in the remarkably short time of 70 days. On 230 miles of this line, two and one-half miles of pipe were welded per day per welding gang.

The record of pipe line construction during the year 1936 indicates a wider use of the electric-arc process of welding in proportion to the total number of miles of pipe lines laid, than for any 12-month period in the nine years since the process was first employed in pipe line construction. The total miles of pipe lines, including oil, gas, and gasoline lines, laid during 1936 and welded by the electric arc, are shown in Table 3. Typical pipe line welding scenes of 1936 are shown in accompanying illustrations. In 1928, the first year in which a pipe line was welded by the electric-arc process, the percentage of electric-welded lines to the total miles of lines constructed was only 9½ percent.



Scene during construction of pumping station on Shell Oil Company's 300-mile crude oil line in California

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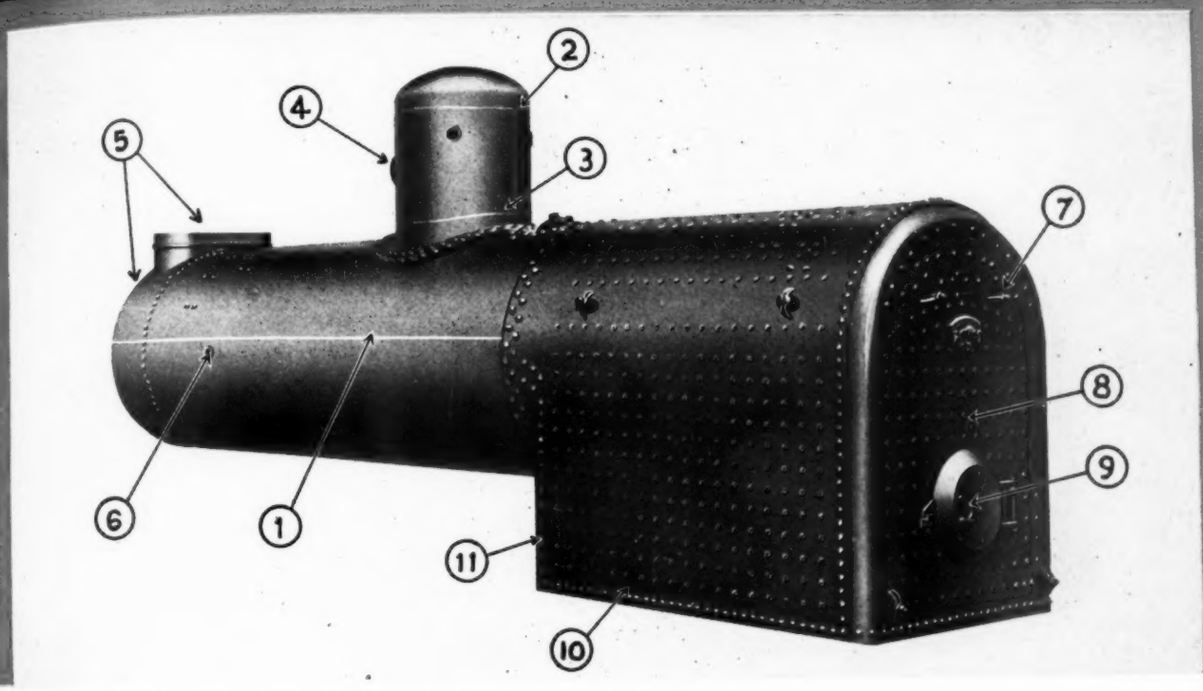

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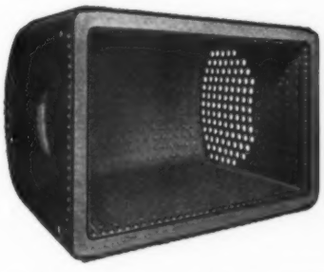
12 (a) F & T RIVETED FIRE BOX*—Mudring corners notched for tight joints; seal welded.



12 (b) F & T WELDED FIRE BOX*—All weld stresses relieved. No staybolts outside of welds.

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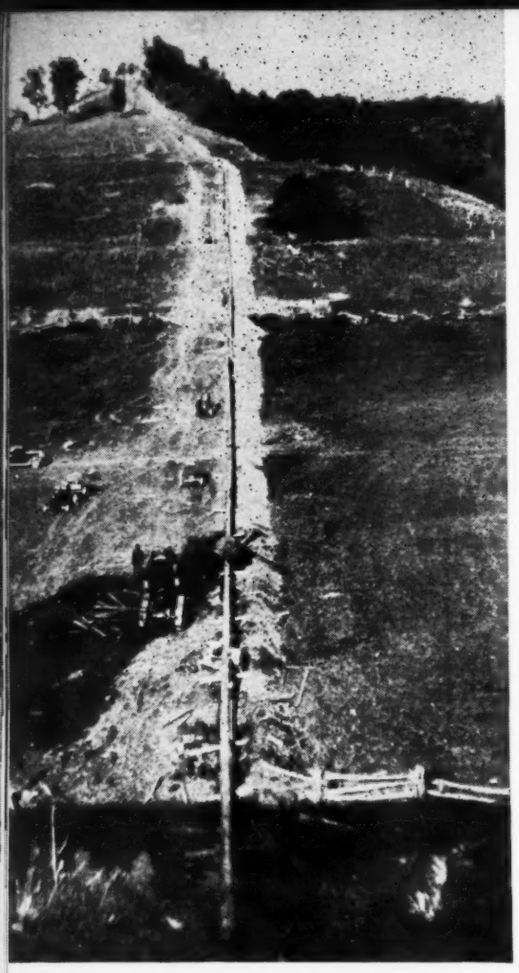

An unusual view taken during construction of Hope Natural Gas Company's 12-in. line from Clendenin to Hastings, West Virginia. The "stove-pipe" method was used

It is interesting to note that during this nine-year period the sizes of pipes most widely used in the construction of lines were of 10-in., 12-in., and 16-in. diameter. Of these three sizes the

Interior of one of Shell Oil Company's pumping stations on California line while under construction

amount of 12-in. pipe used was approximately twice that of any other size. From 1928 to 1936, 4422 miles of 12-in. pipe were electrically welded in pipe line construction. Pipe of 10-in. diameter came next, 2248 miles being laid. Of 16-in. pipe, 2007 miles were laid by electric welding. Table 4 shows the number of miles of pipe lines of various size pipe arc-welded for the last nine years.

Laying a gas line in one of the southeastern states

TABLE 3*

Year	Total Miles of Pipe Lines Constructed	Total Miles of Pipe Lines Electric-Welded
1928	4500	430
1929	7500	825
1930	20731	1750
1931	15360	2350
1932	2250	675
1933	3000	1100
1934	3250	1550
1935	4500	2700
1936	5930	4500

*From data the author believes reliable.

TABLE 4

Miles of Pipe Lines Electric-Welded of Various Sizes of Pipe*

Year	8-in.	10-in.	12-in.	14-in.	16-in.	18-in.	20-in.	22-in.	24-in.
1928	43	65	140	22	56	26	38	15	25
1929	83	124	264	41	107	50	74	30	52
1930	175	263	560	88	228	105	152	68	105
1931	136	178	350	118	300	141	282	375	470
1932	68	101	206	34	88	41	61	24	42
1933	110	165	352	55	143	66	99	38	72
1934	155	232	465	78	200	93	140	70	117
1935	270	400	725	135	300	217	298	137	218
1936	450	720	1350	225	585	270	405	225	270
Totals	1490	2248	4422	796	2007	1009	1555	982	1371

*From data the author believes reliable.

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YOUNGSTOWN

Advancements in Protection of Pipe Lines From Corrosion

Problem has been attacked by metallurgical changes in pipe material, improved methods of applying coatings, and various methods of electrical protection

By DAVE HARRELL
Corrosion Engineer, Houston Pipe Line Company

Fig. 1. Clamp over leak in 18-in. line. Pipe has been cleaned and primed

THERE have been four chief channels through which the corrosion problem has been attacked in the last few years. The first of these consists of metallurgical changes of the materials used in the manufacture of pipe. New and important alloys of cast-iron, steel, and copper pipe have been developed and these only await their commercial exploitation through quantity production to compete with all other present methods of attack on corrosion.

There also have been important developments and discoveries by the manufacturers of the non-ferrous group, and glass pipe and glass-lined pipe already have begun to replace the old metal tubes in chemical plants and refineries. This, too, shortly may be an important means of combatting corrosion on oil and gas lines.

The two avenues of attack mentioned can only concern unlaid pipe lines. The two that concern old lines already in the ground are improved methods of applying coatings to such lines and various methods of electrical protection. The Houston Pipe Line Company has developed a technique for replacing old lines in corroded areas with reconditioned pipe and also for reconditioning a small section of pipe at each leak repaired.

Fig. 1 shows a clamp over a leak on an 18-in. pipe line. The pipe has been thoroughly cleaned and primed with a special blended primer. Over this is poured hot asphalt of the 165-deg. melting point class. In order to render this asphalt waterproof a light coat of grease is rubbed over its entire surface. In order to allow the grease partially to penetrate the asphalt before it is removed by water or soil the whole pipe is wrapped with 80-lb. kraft paper. The company has found that it has been necessary to return to very few of these leaks that were repaired in this manner for the purpose of repairing additional leaks adjacent to the original hole in the pipe.

The second and entirely different process concerns the replacing of the pipe in badly-corroded areas with reconditioned pipe from other places. The pipe is removed from the ground and hauled to a central reconditioning

Fig. 2. View of a central reconditioning station

Fig. 3. Sand-blasting 12-in. pipe at the Edna, Texas, plant

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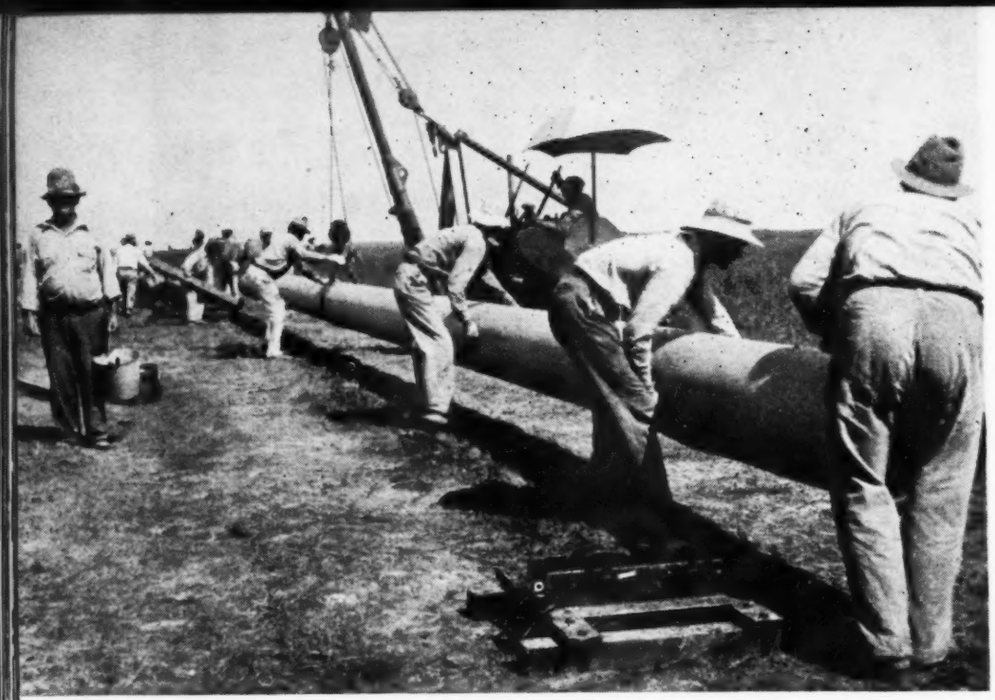

Fig. 4. Handling a long welded section of 18-in. pipe that has been coated and wrapped

station as shown in Fig. 2. The first operation it undergoes upon arrival is to be cleaned and sand-blasted, as shown in Fig. 3. After this it is carefully checked and graded into grades one, two, three, and junk pipe. Pipe of No. 1 grade is such pipe as has retained at least 85 percent of its original wall thickness and on which it was not necessary to do any spot-welding of deep pits or strengthening of seams. Pipe of No. 2 grade is that on which there are not more than 15 spot welds, no bad seams, is considered to have been reconditioned as good as new and will successfully withstand mill-test specifications. Pipe of No. 3 grade is that which can be used only for low-pressure service due to bad steel, weakened seam condition, or excessive number of spot welds. Pipe beyond repair due to the welding expense necessary to reclaim it exceeding its value is junked and used to make pipe clamps and other miscellaneous home-made articles, including its use as anodes for the application of cathodic protection.

After the No. 1 and No. 2 pipe has been thoroughly reconditioned and primed with pitch enamel primer it is hauled to the location where it is to be placed back in service on the high-pressure line. If the replacement line is to be a solid welded line it is strung out in sections, placed on skids, and welded. Next it is carefully coated with pitch enamel by revolving the pipe on dollies. Before it is removed from the dollies it is checked with a holiday detector. All holidays found are repaired and the sections wrapped with heavy kraft paper.

It is at this point that the real skill of a pipe-line construction foreman shows up to best advantage. It is fairly easy to get a good coating job on large-diameter pipe, but to lay this pipe in the ditch with as little breaking of the coating as possible is a real undertaking. Pitch enamel coatings have been recognized as being the best possible coating materials to use on lines of this character, but they are inherently brittle by nature and subject to abrasion by any sharp objects with which they might come in contact or can be cracked, shattered, or cut by wire lines. Fig. 4 shows a caterpillar tractor with boom attachment picking up a long welded section of coated pipe. Note the rubber belt sling around the pipe and how carefully the men are guiding it as it is being lifted. It is next placed over the open ditch on skids padded with old rubber tires and welded up ready to go into the line. Fig. 5 shows the lowering-in operation on a long section of welded pipe. The tripods and hand hoists are used to lower the pipe slowly into the ditch. The same rubber belt type slings are used around the pipe and a hole is dug beneath each to allow them to be withdrawn easily after the pipe has been lowered in.

Fig. 5. Lowering-in operation on a completed section of line

Very often it is expedient to couple a pipe line instead of welding it. When it came to getting a good dope job on the couplings of such a line a big problem was encountered, which was overcome in the manner shown in Figs. 6

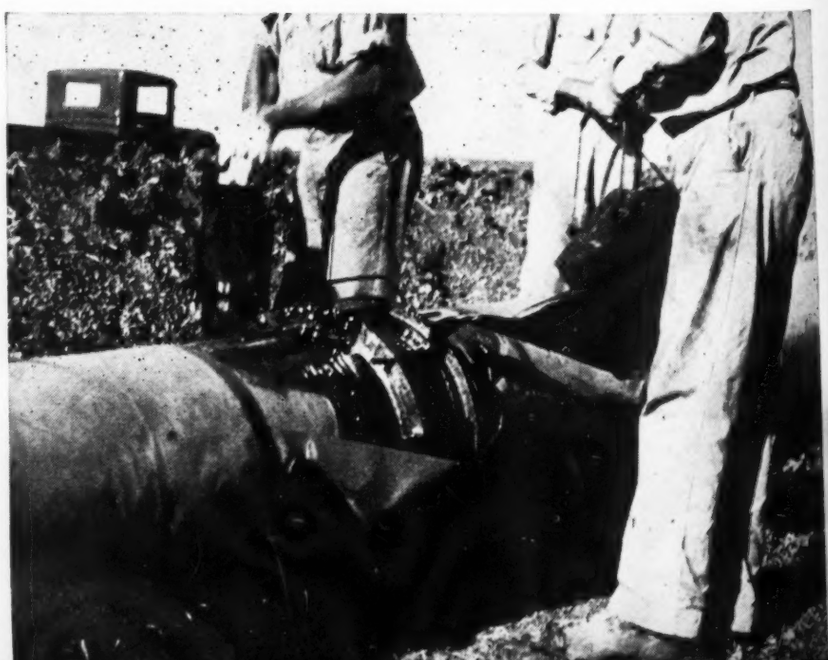

Fig. 6. First step in applying coating to a coupling

WHEREVER YOU TURN

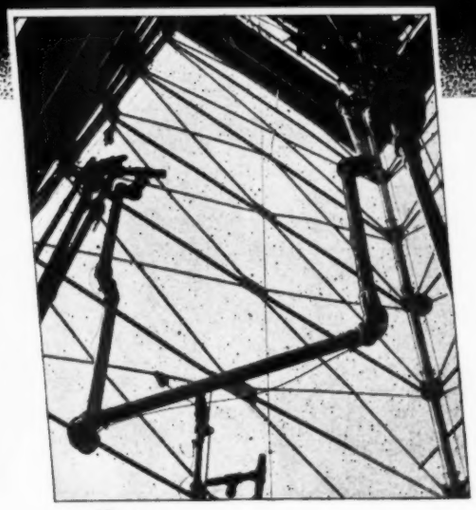

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Fig. 7. After coating has been poured over coupling the operation looks like this. Note how the heavy kraft paper sags. It is full of coating material

Fig. 8. The inspector repairs spots where coating has been applied defectively

Fig. 9. The finished job

to 10. Coupling compound of the pitch enamel type is used and the coupling is first bonded with a heavy copper wire. It is next primed with pitch enamel primer and the bottom half wrapped with a double thickness of heavy kraft paper. In Fig. 6 this happened to be 36-in. width paper, as this was an 18-in. coupling. This paper is secured on either side by heavy luggage straps that are pulled up tight against the buckle to prevent leakage around the edges. Next the top is completely poured with hot dope by the two men with pouring buckets, one standing on either side of the pipe as shown. This pouring operation is continued until the top of the coupling is thoroughly covered and the paper is full of hot dope, thus dipping the bottom half. Next a flat catch pan is held beneath the coupling and one handle held by either man. One of the men rips the bottom of the paper with a welding rod and allows the surplus hot dope to run into the pan, from which it is returned to the heating pot. The straps now are removed, as shown in Fig. 7, and the paper left sticking to the bottom half of the coupling, while Fig. 8 shows the coupling inspector with a bucket of hot dope and a daubing brush; he inspects the job of coating the coupling and repairs any skip spots he may find. He then covers the top half of the coupling with another piece of paper to prevent the back-fill from damaging the top half. Fig. 9 shows the finished job, which looks like a product of the wrapping desk of any big department store.

Exactly the same lowering-in process is employed on coated lines as was previously described on welded pipe except that even greater care must be taken not to allow the couplings to strike against the walls of the ditch while lowering-in. Fig. 10 shows this lowering-in operation of a long section of coupled line. The sad part of this story is that even after the exercise of every precaution in meticulously applying this pipe coating and laying it in the ground, heavy currents can be drawn between this pipe line and an external ground showing that holidays and abrasions exist in this line in spite

Fig. 10. Lowering-in an 18-in. coupled line

of everything that has been done to prevent them.

It is here that we come to the fourth means of attacking corrosion. Where low voltage a-c. mains are nearby, and service can be had at a reasonable figure, coated lines can be protected economically by rectifying this current and feeding it to the pipe from a buried anode. The power thus fed should be raised until the line assumes a negative potential of at least .25 volt. The amount of current will be directly proportional to the number of holidays and abrasions still left in the coating job. In some instances it is possible to protect a mile of large diameter coated main with as low as 50 watts.

Purchased power is not always available and sometimes even if it is, the cost of installing suitable transformers and rectifiers is prohibitive. Under these circumstances another source of

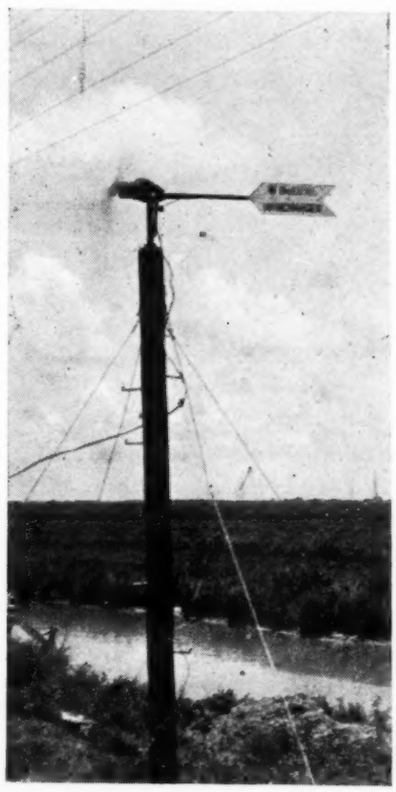


Fig. 11. A 100-watt windcharger mounted on a telephone pole

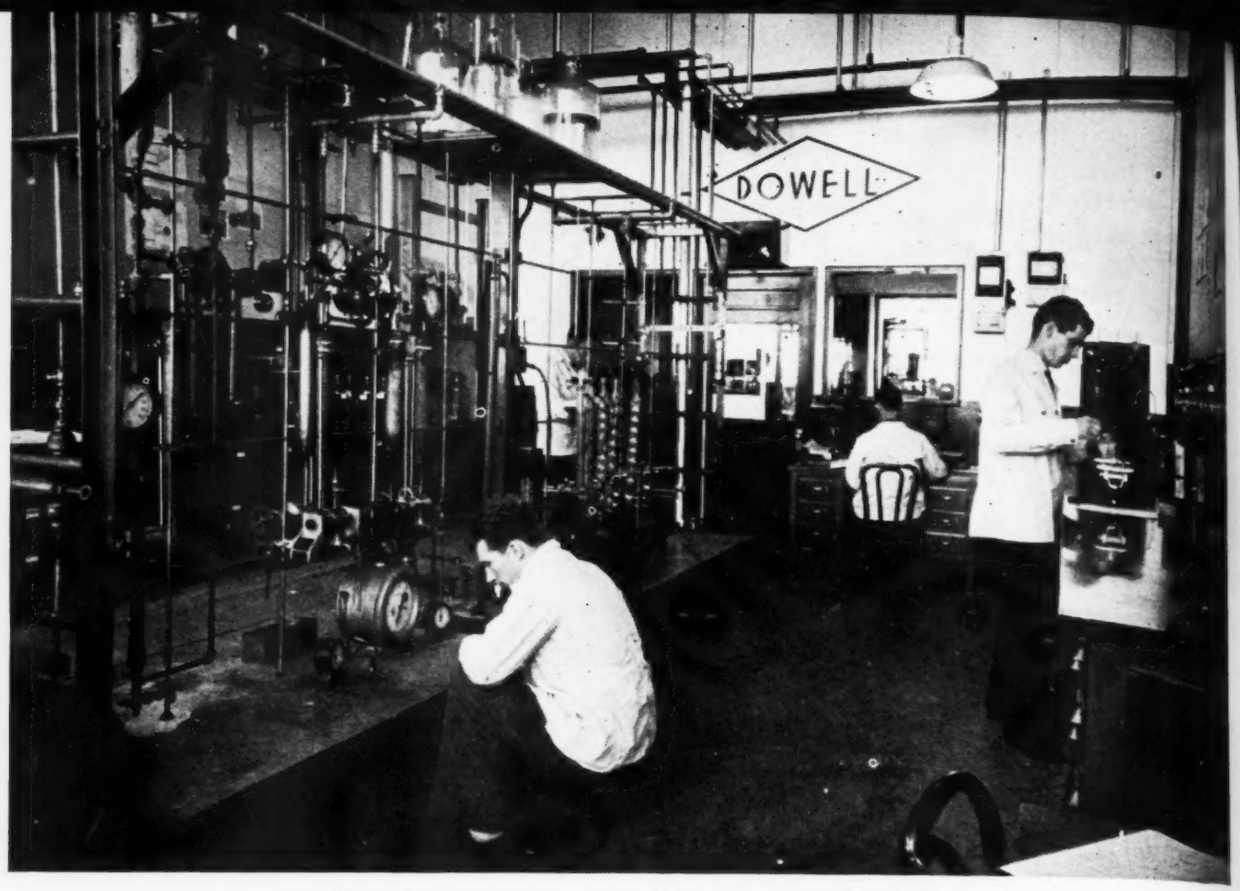
power had to be found. In 1934 and 1935 the Houston Pipe Line Company installed several small wind-driven generators, like the one shown on top the telephone pole in Fig. 11 These have proven highly successful, mechanically reliable, and provide cathodic protection about 75 percent of the time in this Gulf Coast area where the average wind velocity is nine miles per hour.

There are areas, however, where this windcharger system will not operate due to too great a load from poorly-coated lines or lack of sufficient wind to drive them. Under these conditions operators of a natural gas carrier will find it most economical to install small gas-engine-driven generator sets to provide a steady source of direct current for cathodic protection. Such a unit was described in detail in the April, 1937, issue of *The Petroleum Engineer*. This unit requires attention at least once a day and cannot be placed in an inaccessible location.

An attempt also has been made to control the direction of flow of the galvanic currents, thus causing the very factor that was responsible for the destruction of the metal pipe line to protect it. This process also was described in detail in the December, 1936, issue of *The Petroleum Engineer*. So far the results seem entirely satisfactory, as will be seen by the condition of the galvanized coating in Fig. 12.

In conclusion it looks as though each set of circumstances has its own particular solution and it is going to be up to the corrosion department of the pipe line in question to decide which course to choose in selecting a means of combatting corrosion in any given area. An extensive study of individual corrosion problems is going to have to be made to determine which is the most suitable to any given set of circumstances. A great deal has been accomplished, but the field is still wide open for improvements to the present technique of corrosion prevention; much still remains to be done before complete protection is accomplished.

Fig. 12. Galvanized-iron coating job over asphalt and grease after year in ground



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Review of Progress and Trends in Acid Treating Oil and Gas Wells

Process definitely has passed beyond the experimental stage, being accepted as a valuable special technical service to the petroleum industry

By HARRY F. WRIGHT[1]

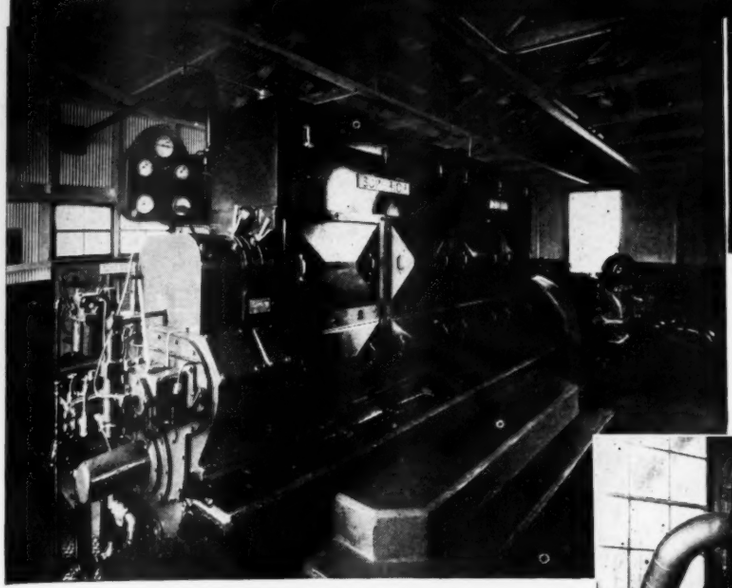
THE acid treatment of oil and gas wells now definitely has passed beyond the experimental stage and has become accepted as a valuable special technical service to the oil industry. The "acid-dumper" and the racketeer are gone, and into their places have come the geologist, the engineer, and the chemist with his laboratory. The acid-servicing business has dwindled from a score or more of panacea-peddling cut-price treaters to a few reliable organizations, each of which is manned by individuals competent and experienced in its various technical phases.

The technology of acid-treating requires the highest degree of skill on the part of the geologist, the engineer, and the chemist. The first two have been tried and long accepted as valuable aids in the finding and production of oil and gas. Chemistry likewise has been an invaluable and indispensable adjunct to the refining of oil; but it is probable that the process of acid-treatment of wells largely, if not wholly, is responsible for the present "chemical-mindedness" of the producing branch of the industry. The inter-relation of these three branches, emphasized by progress in acid-treatment, has been forced upon the consciousness of many technologists previously steeped in their own problems. Executives also have reacted to the extent that reasonable expenditures of money and time in the acquisition of scientific data readily are allowed. Though the value of scientific skill and knowledge in the solution of production problems already was realized by the industry, the immediate profit-producing results achieved by science in the process of acid-treating has had an undoubted effect in aiding the technologist in obtaining sympathy and assistance in the solution of many problems.

Perhaps the greatest and most far-reaching effect of acid-treating on the industry is the complete change in the attitude toward limestone production. Witness the intense and widespread activity in Western Kansas, in which area the various producing horizons are almost all limestones. Without acid the spread of development in Michigan might never have occurred and certainly the present intensive stage would long have been delayed. We like the Permian Basin now; and tales of what might happen in Kentucky are

[1]Consulting Petroleum Engineer and Geologist.

Superior DIESELS IN PIPE LINE STATIONS



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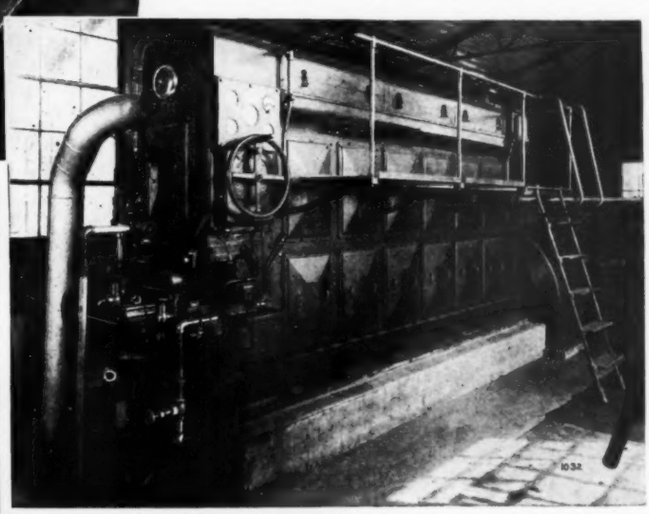

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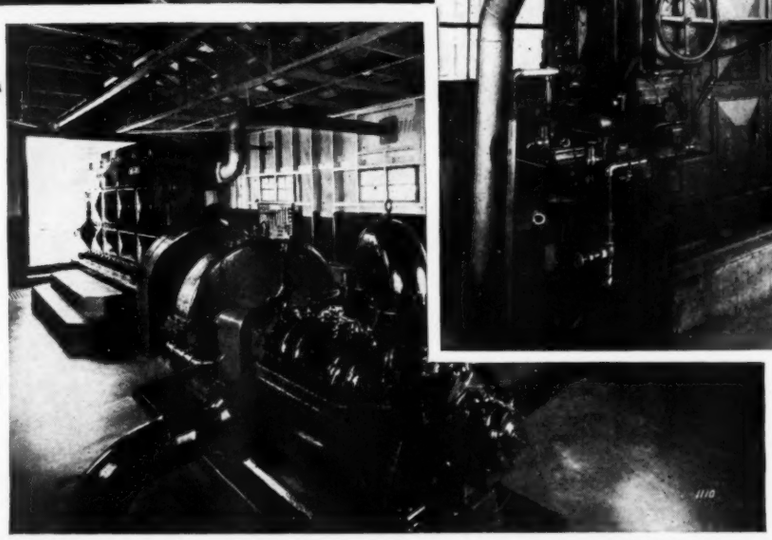

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listened to with interest rather than amusement. The knowledge that production might be found in limestone has intensified rather than stemmed the activity in Northern Louisiana; Wyoming and other Rocky Mountain areas have "perked up" to a distinctly noticeable degree. All this in the five years since acid first got oily, and in spite of the fact that never in that period has there been apparent anything like a shortage of oil nor has there ceased to be somewhere within oildom an excess of production under curtailment by proration.

The acid-treating companies are following the general trend toward study of and research into their particular problems, which has been witnessed before in the development of well-shooting, cementing, and other specialized services. Because the work so widely embraces all the sciences and the "by-products" of such studies reach out so many different ways into oil-production practice, however, their effect is not fully comprehensible. The major companies that have their own technical staffs are receiving incalculable benefit from the service companies, in large degree because the experience of the latter reaches a scope hardly to be expected within the operations of even the larger producing organizations. The small company and the individual operator who treats a well or wells gets, whether he asks for it or not, the benefit of technical advice and the experience of others that he may never have been able to afford for himself. It is only the operator who knows more about it than the service company who is likely to find himself short when the results are inventoried.

CHEMISTRY

While the chemical reaction of hydrochloric acid with limestone itself is very simple, the matter of disposal of residue products of this reaction and those compounds that may be freed in the formation as a result of the breaking-down of acid-soluble salts has come in for much study. The deposition of insoluble residues, whether a direct or secondary result of the acid reaction, may reduce or even nullify completely the salutary effects of opening the pore-spaces with acid. Though it is important properly to introduce acid into the limestone it is equally important to get the resulting products out.

Much work has been done, and still more remains to be done, on the problem of interfacial tensions as between the fluids in the hole. Obviously, if acid is prevented from coming into contact with the walls of the pore-spaces because of a film of oil or occluded water thereon the purpose of introducing acid is not completely accomplished. Likewise, if interfacial tensions as between acid-oil and acid-water may be controlled it will be possible to introduce into the formation a solution that readily will penetrate the one but be much more restricted in its entry into the other.

The higher the concentration of acid put into any given formation the higher is the specific gravity of the resulting calcium chloride solution, and the greater the difficulty of its removal from the reservoir after the reaction is completed. The maximum concentration of acid that may be used efficiently varies with the character of the reservoir. The attempt to control specific gravity of resultant products has gone so far in some instances as to introduce a high-concentration of acid to gain a quick, intense reaction close to the hole and then remove it before the reaction is completed to the point of producing a too-heavy chloride residue.

The removal of insoluble residues still is largely unsolved. It may be said that practically any limestone porous enough to constitute an oil or gas reservoir contains a high percentage of sand, clay or shale, gypsum, anhydrite, etc., that is insoluble in acid. Much of this may be freed from the limestone matrix when the latter is dissolved, to remain in the formation as a potential pore-clogging slime. In wells having a low formation pressure and consequent low velocity of flow, not much can be done now toward removal of these insoluble residues beyond keeping the resultant liquids as fluid as possible.

GEOLOGY

Acid treatment has added nothing to the well-established methods of geologic study except to intensify many of its phases. Much more coring is being done in limestone areas than ever before and much more time and money is being spent to obtain complete core-sections. Core analysis now includes qualitative and quantitative determinations of core materials as well as more extensive studies of porosity and permeability.

It long has been recognized, but not fully realized, that practically every known important zone of limestone production lies at or near an erosional unconformity. The porosity of most limestone reservoirs is largely secondary; the result of leaching by meteoric waters during periods of emergence at an ancient land surface. Intensive core analysis proves that the physical and chemical characteristics of two limestones in proximity to each other may be widely different. If both are actual or potential oil-producing horizons an acid treatment that is

Diesel-powered 4000-gal. unit for acid-treating wells

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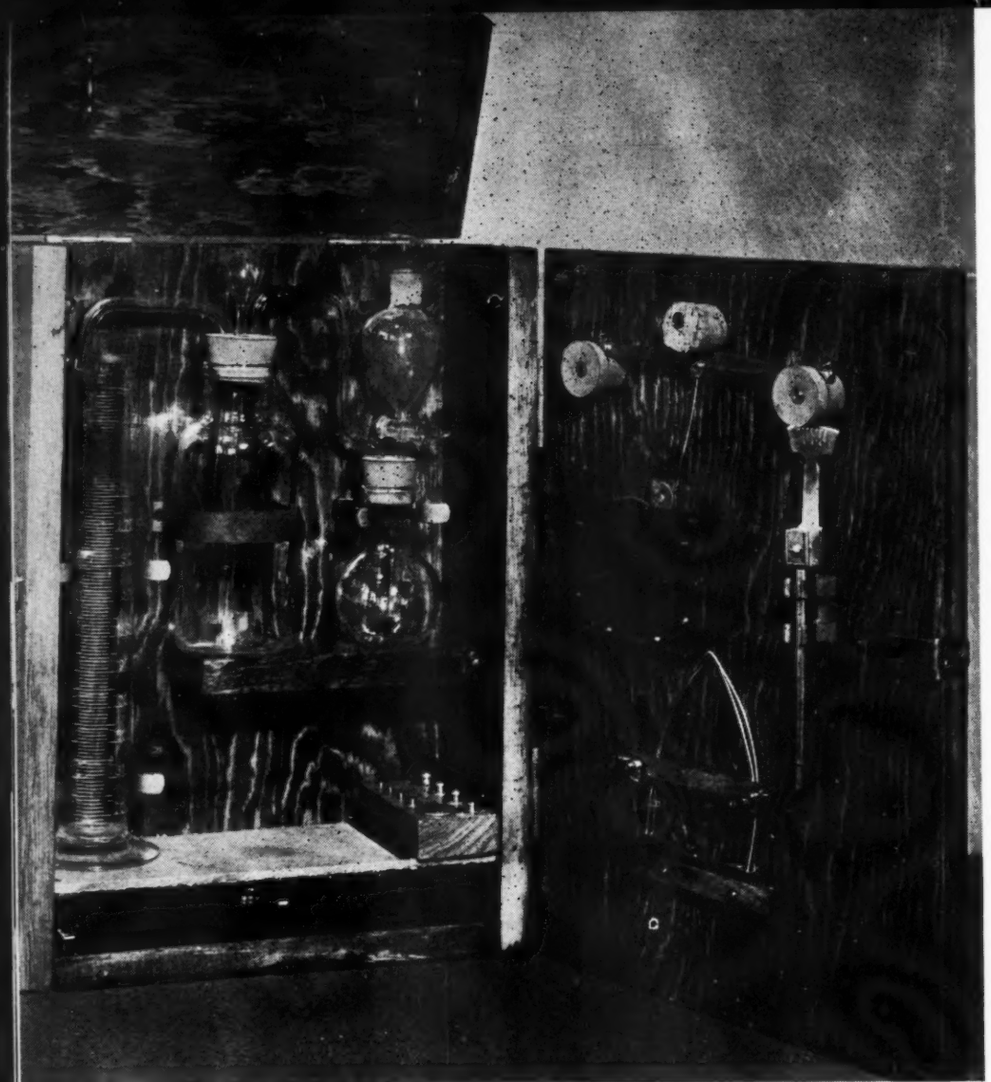


Portable solubility test apparatus

manna for the one might be poison for the other.

The growing use of Schlumberger surveys has been of incalculable benefit in determining the possibilities for acid treatment. The combination of a Schlumberger log and core analysis has revealed in numerous instances that a relatively porous barren streak was taking the acid away from an adjacent saturated but less permeable one, and has identified their exact positions. Vertical porosity caused by solution cavities or by minor fracturing frequently is revealed in a Schlumberger log.

SELECTIVE TREATMENTS

More complete knowledge of the physical and chemical characteristics of limestone horizons has resulted logically in improved methods of acid-treatment. Where it is definitely known which parts of a limestone section are productive and which are barren or contain water, steps may be taken to introduce acid into the one while insulating against the other. Methods now in use lack much of being complete, but great progress is being made.

In some cases where conditions are favorable the time-honored method of confining the fluid to the space above or below a packer is still used. In other fields, where several pay zones are known to be present each is treated with acid as it is penetrated and before the next lower one is drilled. Where neither of the above is possible or practicable the idea is to treat each one successively from the bottom up by filling the hole each time to the bottom of the zone into which it is desired to place the acid.

The ordinary way to accomplish this is to bridge the hole or fill it with mud, rocks, or other non-compressible material. This method has the positive advantage that the top of the plug may be determined accurately by running a measuring line. It has the disadvantages of requiring extra down-time for the well, and the use of equipment that already may have been removed or is not readily available.

There is much work being done toward the development and use of specially-prepared congealing heavy fluids for filling the hole. Such fluid must, of course, be insoluble in acid, oil, and water; must be sufficiently fluid for ready introduction through the well tubes, and must congeal promptly at the bottom of the hole without entering the formation; must withstand high temperature and very high pressure; and must be readily removable from the well after treatment is completed. The use of heavy fluids has the distinct advantage that it requires no advance preparation of the hole nor equipment other than that used for acid servicing; it may be placed in the hole by the acid contractor immediately preceding the treatment and involves only a slight addition to down-time for that purpose; and it may be removed from the hole without use of additional servicing equipment. The chief disadvantage of the method is doubt about the position and condition of the material after it is placed in the hole, as the quantities necessary to accomplish the desired fill-up must be calculated.

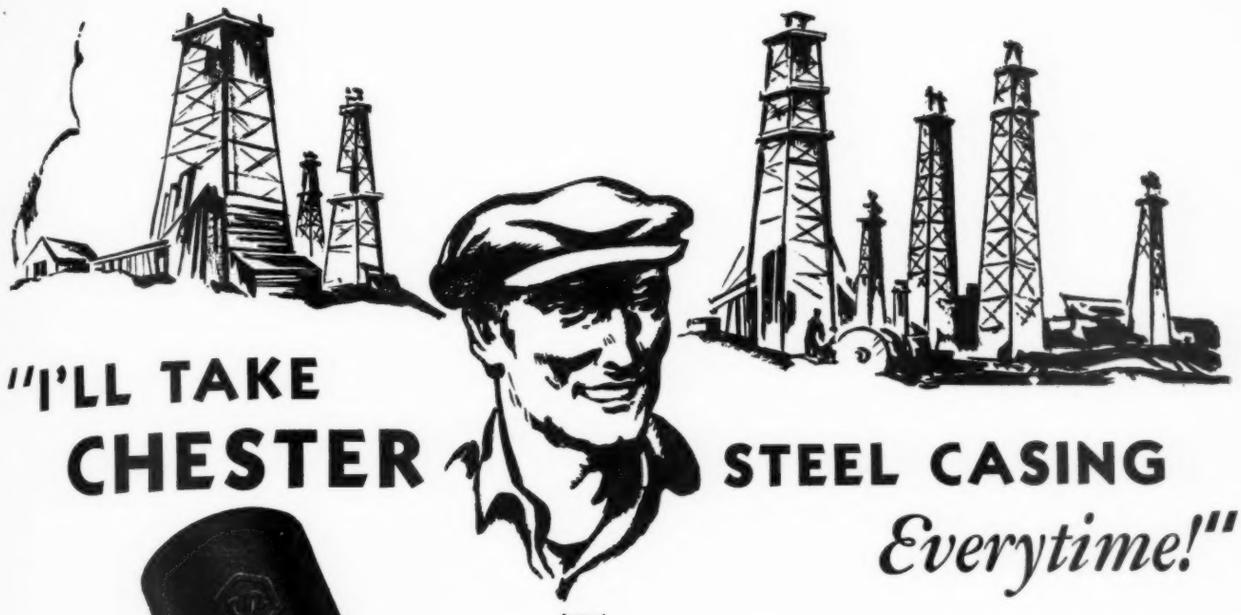
A very recent development in the use of congealing fluids is their introduction into the hole in "slugs" with the acid. The idea is to plug successively the more porous sections and force the acid into the less permeable ones.

Recent work in the use of temperature surveys after cementing, to determine where the cement is, may have an application in acid-treating. It is not yet determined that the heat of the acid reaction is sufficient for the position of the acid to be determined by temperature surveys of well fluids following acidization, but the idea does have some very interesting possibilities.

The results that may be accomplished by selective treatments are almost limitless in scope and the engineering departments of many operating companies, as well as the service organizations, are engaged in their intensive study. If formations containing oil, gas, or water separately may be acid-treated for one with little or no effect upon the others, it means that gas-oil and water-oil ratios may be corrected intelligently. It also means that reservoir energy may be more effectively controlled and conserved.

EFFECT ON OPERATING PRACTICES

There is no question that the use of acid, and of other chemicals employed as adjuncts to acid treatment, has made the producing departments of most oil companies more "chemical conscious" than ever before. The simplicity and safety of methods of introducing into and removing from the hole chemicals designed to accomplish certain results quickly have been



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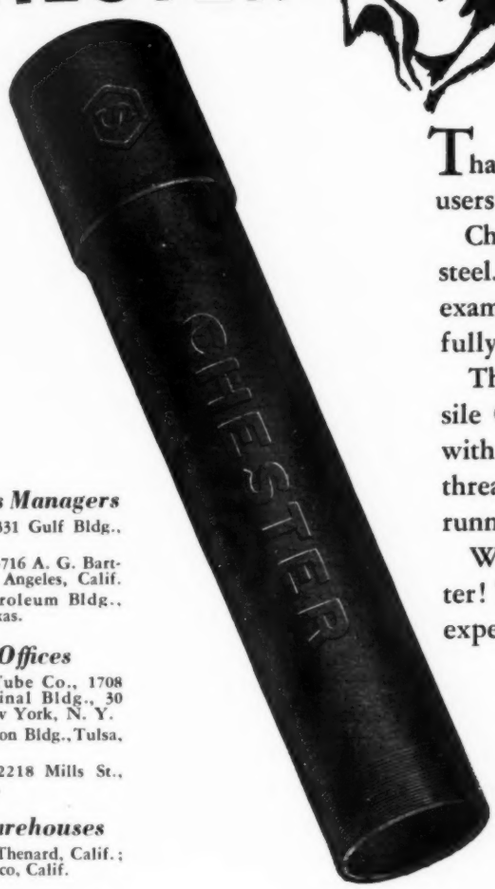
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STEEL CASING AND LINE PIPE

noted. More detailed geologic and chemical studies of producing formations and the fluids contained therein have resulted in improvements in production methods and equipment that in some instances are only remotely connected with acid work. In one instance corrosion of balls and seats formerly charged to acid was found to occur in an identical manner in wells that had not been acid-treated. A change in equipment and corrective measures directed against the normal well fluids and not specifically against acid corrected the difficulty in both types of wells.

In areas where limestone production predominates the prospect of immediate or future treating with acid is considered in the plans for completing, equipping, and operating the wells. Types of equipment and methods of well hook-up are modified, particularly where it is known that high pressures may be necessary in the acid treatment work. Casing and cementing practices have been revised where it was anticipated some formation or other later may be treated with acid. Where several pay streaks occur in the same zone of production, as at Fitts for example, the drilling-in and completion of the wells are done in the light of desirability or necessity for the use of acid.

GALLONAGE USED

When one considers the thickness and porosity of producing formations and the results desired of acid treatment it is evident that the 500-, 1000-, and 1500-gal. "shots" originally injected into most wells were ridiculously small. With carefully planned treatments designed to accomplish specific results the amount of acid used steadily is increasing. One company reports that the average size of hundreds of treatments a year ago was around 2200 gal., and that this year the average of an even greater number of wells is more than 2800 gal.; 10,000 gal. and more are common, and 15,000 gal. is not unusual. Most of the larger treatments now are divided between two or more formations. The maximum amount injected into any one pay probably is not in excess of 6000 to 8000 gallons.

It is common practice to make the injections of acid in stages of various sizes and with intervals of time varying from an hour to a day between them. Depending upon conditions in the particular well or field, stage treatments of 1000-3000-5000 gal., 2000-4000-6000 gal., and 2000-4000-8000 gal. are in common usage. The quantities of acid used and time intervals between the stages usually are dictated by company engineers.

The multiplicity of solubility tests effectively has proven a fact noted early, that the complete acid-limestone reaction was effected in a remarkably short time. As a result the steady trend has been to shorten as much as possible the time required to get the acid into the hole, and to reduce tremendously the time the acid is left in the hole before removal. The average treating time of some 12 hours is not much reduced, but taken in connection with the greatly increased gallonage there has been a material increase in gallons placed per hour. This has been accomplished largely through the use of higher pressures in treating. Two years ago treating pressures in excess of 1000 lb. per sq. in. were unusual. Today 2000 lb. excites no comment, and 2500 lb. to 2800 lb. are readily accomplished. This could not have been done without the willingness of operating companies to employ expensive high-pressure equipment in well hook-ups.

Where the acid formerly was left in the hole from one to three days, the present average time probably does not exceed 12 to 15 hours. In many instances the allowed time is only six or seven hours.

REPEAT TREATMENTS

The desirability and effectiveness of making repeat treatments is a matter individual to the well. Previously, second and third applications of acid were made, if at all, with a period of weeks or months elapsing after the first one. Some of the present stage treatments are in effect retreatments, with only a period of hours elapsing between doses of acid. In the older practice time was allowed for testing after each shot of acid; the present method allows none, or at least a very short one.

The best means of determining the desirability of retreating is the history of the first application. If the treatment ends up with fluid going in under vacuum it is probable that any further quantities of acid would only follow the course of the first and give no significant result. If pressure is maintained throughout the first application, a second is likely to be effective.

Considerable numbers of successful retreatments are being made that are in effect selective treatments. In general it may be said that the lower portion of the producing formation open in the hole is the most porous, usually because drilling stopped at the most prolific horizon. If a second treatment has been made of such a well it is probable the second shot of acid followed the first into the porous lower zone. By filling up this lower portion of the pay zone and treating the upper part many successful retreatments are being made.

METHODS AND EQUIPMENT

With exception of variations in the manner of accomplishing the work, there has been little change in field methods. Better equipment designed for the purpose, coupled with better preparation of the well for the routine as well as special treatments, has made the service company's task somewhat easier. Larger quantities of acid placed in the well at higher pressures require nothing especially new in technique but do require a more precise and careful manner of operation. More detailed records of operating pressures and rate of placing the acid are kept.

The chief advance in field equipment is the use of pumps of constantly increasing capacities in both pressure and volume. Acid treatment has required the development of pumps different from any heretofore used in regular oilfield practice. These units must meet three requirements, viz., large volume capacity, high pressure, and portability. Formerly, separate units, commonly a rotary type for volume and duplex or triplex piston pumps for pressure, were common, but the necessity for handling large quantities of acid under high pressure in a short time practically demands a single unit that can do it all. Acid under high pressure is very corrosive to pump cylinders, plungers, and valves, a pernicious property that necessitates the use of special alloys for such pumps.

Some of the service and operating companies have developed various types of portable laboratories. These eliminate much of the delay incident to sending samples to a central laboratory for determination of solubility and other characteristics. One service company has devised a portable solubility apparatus that is encompassed within a handy carrying case, and can be operated on an ordinary office desk.

Practically all the central laboratories of the producing and service companies are spending much time in research in the advancement of acid-treating. There are at least two such working on these problems exclusively.

The author acknowledges with grateful thanks the assistance of numerous engineers and executives of the service and operating companies in preparation of this review.

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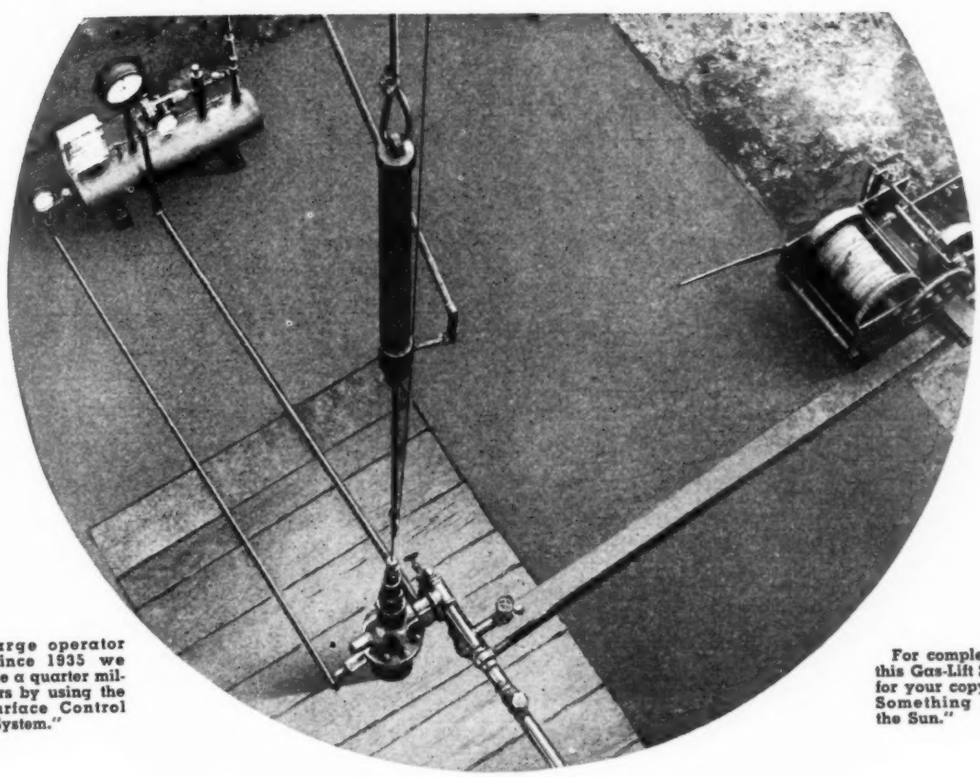

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Recent Developments in Electric Welding of Pipe Lines

By

W. MIKE MURPHY[1]

Renewed construction activity has provided an incentive for improvements to equipment and in field practices

RENEWED construction activity in all branches of the oil and gas industry during the past year has provided an incentive for improvement in electric-welding equipment, welding rods, and field practices. Electric-welding equipment has been developed to a high degree of efficiency. Recent improvements largely have been confined to the adaptation of equipment to a particular welding job, and to reducing operating costs without loss of efficiency.

Gasoline-driven electric-welding machines have been improved in their construction to give them increased durability. An effort has been made by manufacturers to reduce the total weight of these machines, rendering them more portable. Attention also has been given to the design of equipment to simplify repairs, thus extending its useful life. The popularity of gasoline-engine-driven generators is an outgrowth of the standardization of gasoline engines used in the assembly.

Continued improvements have been made in welding rods, the result of demand for rods for specific purposes. Although bare wire electrodes continue to serve a number of purposes, most of the electric-welding rods now used are coated. Realizing that the arc in operation is a small electric furnace, metallurgists design the coatings to enter into the fusion process during welding and refine the molten welding puddle to produce a definite product. Welding rods are designed with special coatings for particular welding jobs, providing a satisfactory welding material for all practical needs.

Better methods of inspection and periodic tests of workmanship have improved the quality of welding. Competent welders have improved technique and established higher standards of practice.

The first uses of welding in the petroleum industry were in the construction and operation of refineries. Prior to the introduction of shielded-arc electrodes there were numerous uses for electric welding where an early fault, the lack of ductility of welds made with bare electrodes, could be tolerated. The development of specially-coated electrodes during the past year has extended the use of electric welding in refineries. Particularly useful has been the manufacture of special electrodes for building up corrosion-resisting surfaces.

There also have been a number of improvements during recent months in equipment, electrodes, and field practices in the construction, maintenance, and reconditioning of pipe lines. Portable equipment has been designed that is sufficiently rugged to meet the hardship of transportation over pipe line rights-of-way. Improvements have

Welding the inside of a crude oil tank

[1]Air Reduction Sales Company.

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Welding a collar on a large-diameter pipe line, using the electric arc

been made in electrodes for pipe line construction, providing greater ductility in completed wells. Failure of a test specimen, either in the tensile or reverse bend tests, is rare with present-day coated electrodes if used by a competent welder on standard pipe.

A procedure of pipe line construction, known as "stove-piping," recently has been applied with a considerable saving in total cost of construction. In this procedure the joints of pipe are tacked in continuous alignment, and all welds are completed with position welding. Qualified workmen, trained in position welding, are required, as well as specially-coated welding rods. Improvements in coating to insure welds of high density, tensile strength, and ductility, have been made.

Pipe line reconditioning work has been active during the year, the greater portion being on the older lines laid originally with screw joint construction. By welding around the ends of the couplings of the line it acquires the leak-proof advantages of an all-welded one. Pits in the pipe are spot-welded. Where serious leaks are found at the couplings, the latter are totally encased. On badly-corroded sections, usually found on the bottom side of the pipe, "half soles" sometimes are welded. When necessary to recondition the pipe without taking the line out of service it is often imperative entirely to encase badly-leaking joints, including the collar. Improvements in operating practices have reduced the cost of reconditioning work and made it possible to put back into full service lines that had been weakened by corrosion, or had shown serious line losses from leaking collars. Most welding in this type of work is done on the lower quadrant of the pipe. Electrodes must have the same qualities as those used on overhead or position welding, and must be such that they will avoid excessive splatter loss.

A large saving of steel has resulted from the use of welding in the construction of steel storage tanks. Originally the plates were lap-welded. Improvements in welding electrodes and welding procedure permit the use of butt-welding with satisfactory results. Owing to the increased manufacture of butane during the past year, a large quantity of steel storage has been erected for this product, which is stored under pressure. Butane storage requires a special method of construction. Welds on this type of storage must be of high quality and absolutely free of pinholes.

In the manufacture of equipment for the oil industry, castings in a large measure have been replaced by fabrication with steel plate using electric welding. This also has simplified repair of broken parts in the field.

Electric welding an 18-in. gas header on a compressor station construction job

Moving Pictures Will Be Featured at Houston Oil Show

Motion pictures depicting all phases of petroleum operations and including the methods used in many foreign fields will be shown daily at the Oil-World Exposition to be held in Houston, Texas, from October 11 to 16, inclusive. These pictures will be of such a variety as to interest men from all branches of the industry and will be entertaining as well as instructive.

A number of technical films have been obtained from various leading manufacturers of equipment and several complete films of particular interest have been obtained from the U. S. Bureau of Mines. These will all be shown in one of the projection rooms at the new exposition building, which is especially equipped for the purpose.

One of the pictures is a three-reel film entitled "Through Oil Fields of Mexico," which was made in cooperation with the American Oil Company (Pan American Petroleum and Transport Company). In addition to the general views around the oil fields of Mexico, this film will show two of the world's best known wells—Potrero No. 4 and Dos Bocas. The former had an uncontrolled flow for about three months with part of the oil being saved by a dam built across the river. Although the picture will present many other such unusual conditions, it also will show the type of equipment used in Mexico, the laying of pipe lines, storage, and refining processes. The shipment of oil via tank cars and tankers, the port facilities utilized and the arrival of oil in the United States will complete the picture of operations.

In a film entitled, "Refining the Crude," a four-reel picture made in connection with the Gulf Refining Company, the crude is followed from the field to its final refined form. This movie will include shots of various refining processes, such as straight distillation, cracking, lube-oil manufacturing, etc. In addition it will show laboratory work, safety, first-aid and fire-fighting methods in vogue and will picture refinery operations up to and including the shipment of refined products to the consumer.

Another type picture will be one entitled, "Petroleum, the Liquid Mineral," made in cooperation with the Pure Oil Company. In four reels, the technique of oil production is outlined and the film shows methods of exploration as well as drilling and production. Both cable and rotary tool operations are included. Methods of production are shown and include the manufacture of natural gasoline. The final scenes depict storage and transportation.

In addition to the moving pictures shown in projection rooms, many of the manufacturers have prepared films for continuous showing in their booths. These will aid greatly in giving visiting oil men an opportunity to see the application of certain tools and machinery in operation and will add to the value of the exhibits in showing the working of equipment.

Reduced Fares

Arrangements have been made with all railroads throughout the United States for a reduction in railroad rates to be granted to oil men attending the Oil-World Exposition. Special certificates are being provided for the purpose and the use of such certificates is necessary to procure the advantage of the reduced fares. Everyone planning to attend the oil show is, therefore, urged to write in for a reduced fare certificate, obtainable by addressing E. G. Lenzner, general manager, Oil-World Exposition, Inc., Petroleum Building, Houston, Texas.

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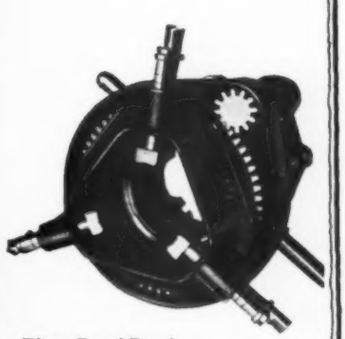

Three Broad-Faced Chuck Jaws Make for Easy, Accurate Centering

"Caterpillar" Announces Promotions

Louis B. Neumiller, former manager of the central sales division for Caterpillar Tractor Company, has been named director of industrial relations for the company, a new post, created because of employment growth.

Neumiller will devote his entire time to matters affecting "Caterpillar" personnel. He will leave the sales department to take office as a member of the administrative staff of the company.

Years of experience with "Caterpillar" gives Neumiller an excellent background for his new duties. He first joined The Holt Manufacturing Company in 1915, and in the engineering department there gained much valuable shop knowledge. He was promoted to superintendent of the drafting room with supervision of construction and experimental models. Transferred to the parts department in 1921, he became general parts manager. In 1930 he was placed at the head of the service department as general service manager. Last January, he became central sales division manager, which position he has held until his present advancement.

C. M. Burdette, former assistant to Neumiller, has been advanced to manager of the central sales division. Burdette came to Caterpillar Tractor Company six years ago from General Motors Company, where he had been associated with the Hyatt Bearing Division as western manager for many years.

Important among his assignments with "Caterpillar" has been the conducting of the 1936 and 1937 machinery shows, which were attended by the company's distributors and included more than 12,000 guests.

Charles A. Spears, who has been supervisor of special representatives, has been promoted to manager of allied equipment sales. Spears has been associated with Caterpillar Tractor Company for seven years. He graduated in civil engineering from the University of California and as a practicing engineer gained much experience in railroading and with Los Angeles County, in California.

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...your Diesel, new or used, not already equipped with them. This is a broad statement — likely to make you lift your eyebrows — that is, if you have never used COOK'S Rings.

It has every foundation in fact, however, for two reasons:

1 —***The scientifically superior design of COOK'S Rings, which stops all "blow-by," is* BOUND *to improve engine power and give more Kw.-hr. per gallon of fuel... while the wear-reducing and wear-resisting properties of COOK'S GRAPHITIC IRON—exclusive in COOK'S Rings—is* BOUND *to prolong cylinder life and save on ring replacements.***

2 —***The great mass of PROOF, in the form of "before-and-after" operating data, that has come in to us—and keeps coming in—from Diesel operators everywhere, showing improvement in performance and savings in operating expense definitely creditable to COOK'S Rings—particularly under difficult conditions of poor lubrication, extreme pressures and high temperatures.***

FIND OUT WHAT COOK'S RINGS WILL DO FOR YOUR DIESEL

Simply send us the make and type of your engine and its performance characteristics and we'll tell you the degree of improvement you may expect by a change to COOK'S Rings. Don't put it off—WRITE TODAY!

C. LEE COOK MANUFACTURING CO.

INCORPORATED

New York Cleveland Baltimore Los Angeles LOUISVILLE, KY. Chicago Tulsa San Francisco New Orleans

James P. Ratigan on European Trip

James P. Ratigan of Los Angeles, California, long and favorably known among oil men and head of the organization manufacturing the Ratigan Sure Grip line of oil field products, left Los Angeles recently for a trip to England, Ireland, and Scotland,

JAMES P. RATIGAN

where he will combine business and pleasure for several months. He planned to sail from New York on the S. S. Manhattan. During his sojourn in Ireland, the land of his birth, Ratigan will visit his brothers, sisters, and a number of old college friends. Returning, he will sail from Queenstown Harbor, Ireland, on September 22nd, arriving in this country in time to attend the Oil-World Exposition to be held at Houston, Texas, in October.

J. H. Fisher Honored

J. H. Fisher, president of the Fisher Governor Company, was honored at a large banquet held recently in the Hotel Tallcorn, Marshalltown, Iowa. This banquet was the concluding event of a three-day sales convention attended by 82 Fisher sales representatives from all principal cities in the United States, Canada, and Mexico.

As a lasting memento of Mr. Fisher's record of 25 years of outstanding success as head of the Fisher Governor Company, each guest at the banquet was presented with a privately-printed, handsomely-bound 85-page book. This beautiful book contains an interesting history of the company and illustrations of the office and factory. Full page crayon portraits of the founder, William Fisher, J. H. Fisher, company associates, and all Fisher sales representatives, are distinctive features of the book.

Notable speakers at the banquet were Governor Nelson G. Kraschel of Iowa and W. A. Sheaffer, president of the W. A. Sheaffer Pen Company.

During the three-day convention talks were given by J. H. Fisher, N. T. Chadderdon, M. V. Cordell, Montreal, Canada; A. W. Shepherd, New York; H. C. Dahl, Los Angeles; Harry T. Porter, Cincinnati; Warren W. Joy, Denver; Fred G. Carter, R. A. Engel, Paul A. Elfers, and Kenneth R. D. Wolfe, all of Marshalltown.

Other highlights of the meeting included inspections of the Marshalltown plant and the new Fisher research department. There also was a golf tournament in which the sales representatives sought to improve scores as much as they have their sales records.

George Nelson Studies Mid-Continent Conditions

GEORGE NELSON

George Nelson, associated with Natural Gas Equipment, Inc., for the past three years, has just completed an extensive field survey of Mid-Continent conditions affecting the application of N.G.E.-Nelson Series 1000 Gas Burners. During this time Nelson operated out of the offices of the Natural Gas Equipment Company of Texas in Houston and covered all Mid-Continent points.

Allis-Chalmers Announce Changes

Oscar A. Hass, formerly connected with Allis-Chalmers Manufacturing Company's Tulsa district office, and recently chief engineer of the Oklahoma Iron Works and International Supply Company, has been appointed manager of that district, succeeding D. M. McCargar.

McCargar, until recently manager of Allis-Chalmers' Tulsa office, has been advanced to the general position of engineer, petroleum industry, for that company with mailing address in care of the company's Tulsa office.

Axelson Employees to Take Vacations Simultaneously

Employees of the Axelson Manufacturing Company, Los Angeles, will all take their vacations at the same time this year, with the result that the plant will be shut down from July 4 to July 10. A skeleton crew, however, will make shipments from stock items during this period. Field stores and warehouses will remain open as usual. Axelson's general offices and branch offices also will be open.

It is pointed out that by giving everyone their vacation at the same time, less confusion results.

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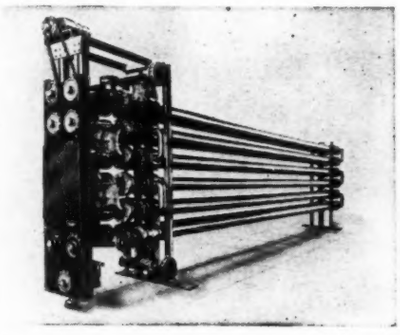
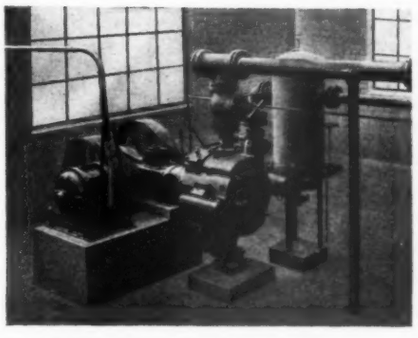


Carbondale Heat Exchanger



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Pacific Oil Show and Black Gold Festival Sept. 16-19

A major oil exposition with exhibits of equipment and services used in drilling, production, refining, and marketing of petroleum products is scheduled to be held in Taft, California, September 16-19, 1937. Taft is making a definite bid for the title of Black Gold Capitol of the West with its plans for a gigantic show to celebrate the state's largest industry.

The show originally was conceived by the Taft Chamber of Commerce, which investigated possibilities of staging such an event. The Kern County Chamber of Commerce aided in the matter and with the help of the Kern County Board of Supervisors appropriated the money necessary for the preliminary work. At a mass meeting of community leaders and leaders of the industry a non-profit corporation was formed to stage the show. E. H. Conklin, who was connected with the San Diego International Exposition, was obtained as managing director and executive offices were opened in the Fox Hotel Building in Taft. Engineers are busy at the present time laying out the grounds where the exhibit will be held.

Franklin Park, one of the finest recreational centers in the state, was selected for the site. Here buildings, convention halls, and amusement features will be built in an effort to bring 100,000 people to the West Side for the four days of the show.

Several million people live within a radius of a three-hour drive of Taft. Black Gold, the state's greatest industry, far topping the famed movies of California, is expected to bring these thousands of visitors flocking to the festival. In addition hundreds of oil men from all over the nation are expected to attend the show.

It has only been 25 years since Taft became the center of the state's largest producing field, producing one-third of the California oil. Operators had become interested in the West Side several years before. Drilling first began in the 1870's. Italians sunk shafts and bailed out the oil in those days. Then on January 1, 1910, with the Oil Land Withdrawal Act taking effect, Taft had its own gold rush, Black Gold, with armed guards protecting stake flags, and violence covered the community.

That same year the famous Lakeview gusher came in during March and until September ran wild, covering the entire countryside with oil, sometimes reaching a record flow of 68,000 bbl. daily. In this historic oil setting is to be staged the Pacific Oil Show and Black Gold Festival.

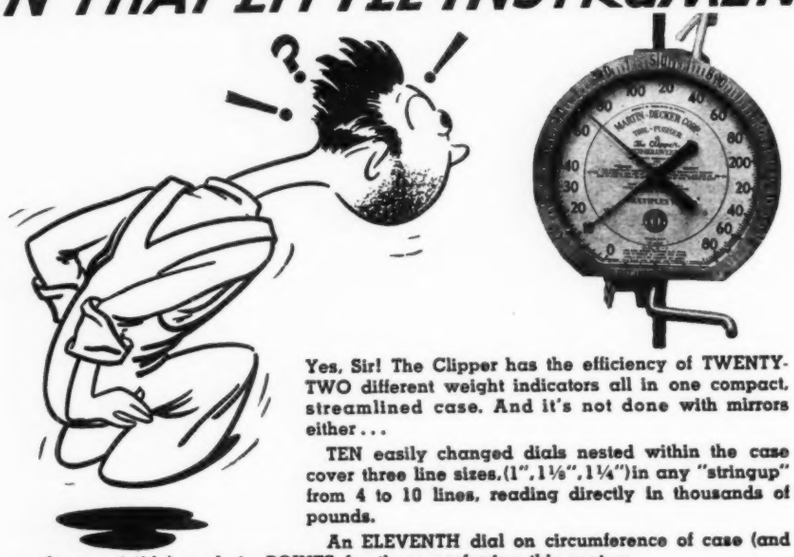
Mid-Continent Supply Opens Two New Stores

The Mid-Continent Supply Company, Mid-Continent Building, Fort Worth, Texas, recently opened two new stores: at Seagraves, Gaines County, Texas, with G. W. Walters, store manager; and at Monahans, Ward County, Texas, with A. E. LeClaire, store manager. Both of these stores are under the supervision of R. C. Tucker, district manager at Odessa, Texas.

Mason Neilan Opens Los Angeles Branch

The Mason Neilan Regulator Company has announced the opening of a branch at 1457 South Concord Street, Los Angeles, California, to provide improved facilities for complete service, including stock for immediate shipment, servicing facilities for regulators, instruments, valves, assembly and calibration of thermal systems, as well as competent engineering advice on control problems.

WHAT! 22 GUAGES IN THAT LITTLE INSTRUMENT



Yes, Sir! The Clipper has the efficiency of TWENTY-TWO different weight indicators all in one compact, streamlined case. And it's not done with mirrors either . . .

TEN easily changed dials nested within the case cover three line sizes, (1", 1⅛", 1¼") in any "stringup" from 4 to 10 lines, reading directly in thousands of pounds.

An ELEVENTH dial on circumference of case (and always visible) reads in POINTS for those preferring this system.

With each of these eleven dials there are TWO gauge hands always at work . . . a regular hand for ordinary work, and a supersensitive hand (six times as sensitive) for extremely accurate work. That gives twenty-two different gauge systems always in readiness.

But that's not all you get in the Clipper!

Controllable Sensitivity on EACH gauge hand allows dampening swing of hands for rough drilling without affecting accuracy.

The etched non-glare numerals are easily read from all parts of the rig, for, although the Clipper is highly compact, no sacrifice has been made in size of gauge dials.

A Lightweight Streamlined Aluminum Case entirely encloses mechanism, making the Clipper Weather-proof as well as Tamper-proof.

Special Bi-metallic compensators eliminate effects of heat or cold upon the instrument. . . The Clipper is always right!

Completely self-contained, the Clipper is calibrated at the factory and arrives at the rig ready for use. Nothing to pump up and nothing to adjust.

And the weight—Only 47 pounds complete. It can be moved from job to job without any inconvenience.

Write today for complete literature!

DO YOU KNOW? —More than a dozen producing wells have been lost in a certain California field because of sub-surface earth movements!

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MARTIN-DECKER CORPORATION

LONG BEACH CALIFORNIA

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Mid-Continent Distributor: REED ROLLER BIT COMPANY, Houston, Texas

Golden Celebration of Oil and Gas on National Broadcast

The hectic days of industrial boom in the gas and oil fields of Ohio half a century ago were recalled in a broadcast from the Golden Celebration of Oil and Gas at Findlay, Ohio, Monday, June 21, from 3:00 to 4:00 p.m., EDST, over the NBC-Blue Network.

Axtell J. Byles, president of the American Petroleum Institute, and R. W. Gallagher, past president of the American Gas Association, were heard as speakers from the dedicatory ceremonies on the site of the new monuments erected at the old Oesterlen and Karg wells, the first and largest gas wells in the area.

In a special human interest feature of the program, three "old-timers" who worked on the Oesterlen well at the time of its drilling in 1887 were interviewed. They were William Vail, who dropped the "go devil" into the well, thus opening its flow and starting the boom; Martin P. McGee, only surviving tool dresser who worked on the well, and George Cusak, one of the original stockholders. Music by a local band completed the program.

The discovery of natural gas at Findlay provides one of the strangest chapters in American industrial history. It was distributed free to factories to induce them to come to the city, but it rapidly became depleted because of enormous waste. It was only the subsequent discovery of the oil fields that saved the city from the loss of its prosperity. The Golden Celebration, June 20-26, was attended by the most prominent oil, gas, and railroad executives in the country.

Johns-Manville Announces Two New Manufacturing Units

Lewis H. Brown, president of Johns-Manville Corporation, has announced that negotiations have been completed for the acquisition of two new properties by the Johns-Manville Products Corporation.

In Watson, suburb of Los Angeles, an option to purchase a 50-acre plot of land has been acquired; and as soon as possible construction will start on the first unit of a new million-dollar factory there.

This new plant will produce rock wool home insulation and transite asbestos-cement pipe, two J-M products that are being widely used on the West Coast and which in the past have been produced by Johns-Manville only at its Mid-West and Eastern plants.

When completed early in 1938, the new plant is expected to employ approximately 300 men, Brown said. Initial plans call for the erection of two cupolas for the production of rock wool home insulation, and facilities for transite pipe production will be installed as quickly as possible.

The second new plant for Johns-Manville was announced upon the completion recently of negotiations for the purchase of the Richmond, Indiana, plant of the Fibre Conduit Company, which is consolidating its manufacturing activities at its Orangeburg, New York, factory. About July 1st Johns-Manville intends to begin the installation of equipment for the manufacture of a new type of low-temperature insulation recently perfected in the J-M Research Laboratories, and which is covered by basic patents. Characteristics of the product include high insulating efficiency and lightness in weight that adapt it particularly for use on railroad passenger and refrigerator cars, mechanical refrigerators, and for sound deadening as well as thermal insulation on automobile bodies.

WHAT IS A
GEOPHYSICAL SUCCESS?

Finding oil and gas accumulations is not the only measure of geophysical success. The function of geophysical exploration is to prevent drilling in the wrong places, as well as to direct drilling in the right ones. To be truly successful, a geophysical method must be able to define accurately not only simple structures, but the most difficult ones as well, and to perform reliably under the most adverse conditions. Measured in these terms

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is a geophysical success. Used almost exclusively in territory hitherto thought unshootable, it has demonstrated its ability to locate oil and gas accumulations through supplying vital structural information never before obtainable.

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I.P.A.A. President Appoints Two Committees

It has been announced at the national headquarters of the Independent Petroleum Association of America that Chas. F. Roeser, president of the association, has appointed a Committee on Public Relations, composed of the following:

Burdette Blue, chairman, president of Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma; F. M. Porter, vice-chairman, receiver for Wirt Franklin Petroleum Corporation, Oklahoma City, Oklahoma; E. L. Smith, 705 Gulf States Building, Dallas, Texas; M. W. Blair, president, United Producers Company, Wichita Falls, Texas; Rolla A. Clymer, owner and publisher, The El Dorado Times, El Dorado, Kansas.

A Tax Policy and Advisory Committee also has been appointed, composed of the following:

E. H. Moore, chairman, E. H. Moore, Inc., Tulsa, Oklahoma; H. B. Alspaugh, president, Southern Oklahoma Oil and Gas Association, Duncan, Oklahoma; William Bell, president, Illinois-Indiana Petroleum Association, Robinson, Illinois; Taylor M. Bishop, president, Ohio Pennsylvania Grade Crude Oil Association, Alexandria, Ohio; R. A. Broomfield, executive vice-president, Barnsdall Corporation, Los Angeles, California; W. J. Brundred, president Brundred Oil Corporation, Oil City, Pennsylvania; Al Buchanan, Al Buchanan Drilling Company, San Antonio, Texas; F. A. Calvert, president, Oil and Gas Association of Michigan, Saginaw, Michigan; J. D. Collett, president, Mid-Continent Oil and Gas Association, Fort Worth, Texas; C. J. Dexter, president, New Mexico Oil and Gas Association, Artesia, New Mexico; J. Wood Glass, president, Northeastern Oklahoma Stripper Well Association, Nowata, Oklahoma; W. S. Hallanan, president, Plymouth Oil Company, Charleston, West Virginia; Jake L. Hamon, president, Texas Division, Mid-Continent Oil and Gas Association, Dallas, Texas; J. C. Hunter, president, West Central Texas Oil and Gas Association, Abilene, Texas; Robert S. Kerr, Anderson and Kerr Drilling Company, Oklahoma City, Oklahoma; E. A. Landreth, president, Landreth Production Corporation, Fort Worth, Texas; Marrs McLean, Beaumont, Texas; L. M. Moffitt, president, Louisiana-Arkansas Division, Mid-Continent Oil and Gas Association, Shreveport, Louisiana; F. B. Plank, Empire Oil and Refining Company, Bartlesville, Oklahoma; J. G. Puterbaugh, president, McAlester Fuel Company, McAlester, Oklahoma; R. M. Riggins, Phillips Petroleum Company, Bartlesville, Oklahoma; Arthur A. Seeligson, vice-president, Slick-Urschel Oil Company, Oklahoma City, Oklahoma; E. J. Shaffer, Hutchinson, Kansas; E. L. Smith, E. L. Smith Oil Company, Dallas, Texas; D. J. Sweeney, president, New York State Oil Producers' Association, Buffalo, New York; T. P. Thompson, Jr., president, Pennsylvania Grade Crude Oil Association, Bradford, Pennsylvania; R. L. Underwood, president, North Texas Oil and Gas Association, Wichita Falls, Texas; Earl D. Wallace, president, Kentucky Oil and Gas Association, Lexington, Kentucky.

Lives up to its name
GRIZZLY
"NO-WIP"
LINE SAVER
Operators are finding that the Grizzly "No-Wip" Line Saver pays for itself over and over in reducing wire line wear to a minimum . . . in the elimination of many line difficulties, in the perfect spooling it makes possible.
With the Grizzly "No-Wip" Line Saver installed on your wire line there can be no friction, stress, strain, or metal-to-metal wear. The device floats with the line and the line itself runs between tough rubber rollers that spin freely at the slightest contact. This smooth, free, floating action also eliminates whipping, crawling, and overlapping . . . all without straightening or injuring the line. Built to boost drilling efficiency and safety, and to cut wire line replacement to the bone.
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New Magazine for Royalty Interests

A magazine for oil royalty interests called *Petroleum Royalties*, the only such publication devoted exclusively to this branch of the petroleum industry, made its initial appearance this week. Andrew M. Rowley, former editor of *The Oil and Gas Journal*, is editor. The magazine is being printed in Tulsa, Oklahoma, with offices of the company in the Midco Building.

The first issue contains articles written by well-known authorities in the petroleum industry on matters of particular interest to royalty dealers, investment houses, royalty owners and investors, and to the petroleum industry as a whole.

Struthers-Wells Company Has New Pittsburgh Representative

Struthers-Wells Company, with manufacturing plants at Warren and Titusville, Pennsylvania, is now represented in the Pittsburgh district by Goldsborough and Vansant, Inc., with offices in the Farmers Bank Building, Pittsburgh.

Refinery Sets New World Record for Safe Operation

A new world's record in industrial accident prevention, the operation of a petroleum refinery for 3,631,697 hours without a single day's loss of work through industrial injury, has been recorded by the American Petroleum Institute's Department of Accident Prevention. The record was established by the Whiting Refinery of the Standard Oil Company (Indiana) between November 24, 1936, and May 10, 1937, the accident-free period being equivalent to a full year's working time from 1940 men under present working schedules.

In 1932 the Whiting Refinery established a record of 2,773,435 accident-free hours. The accident-free period this year ended May 10, when a steam line gasket blew out and caused minor burns on a workman's leg.

Gain in Output of Petroleum Equipment

Output of special machinery for use in the production and refining of petroleum showed a gain of 140 percent in 1935, as compared with 1933, the previous census year, according to information made available by the U. S. Bureau of the Census. Total value of machinery produced for oil company use in 1935 amounted to $62,824,730 as against $26,290,134 for 1933. The 1935 total is made up of $54,893,284 worth of machinery for use in the oil fields and $7,931,446 worth of refining equipment. The oil field machinery item consists largely of drilling equipment, and is the largest single item in the long list.

Special Professors' Welding Course Well Attended

Attesting to the increasing emphasis being placed on welding as a primary process of construction and manufacture was the attendance at a special professors' course in arc-welding design and practice held recently in Cleveland under sponsorship of The Lincoln Electric Company. The course was attended by 23 professors, or instructors, representing 21 different colleges, or trade schools, in 16 different states. The states represented by men attending the course included Massachusetts, Colorado, Mississippi, North Dakota, and Vancouver, British Columbia, Canada, indicating an interest in electric welding on the part of all sections of the country.

The course, which began June 14th and continued for five days, gave those attending the opportunity of intensively studying electric welding in both its theoretical and practical aspects. The ground covered followed in general the advanced five-day course in arc-welding design and practice given regularly at Cleveland by The Lincoln Electric Company in conjunction with the John Huntington Polytechnic Institute. The subjects covered, under direction of E. W. P. Smith, nationally-known welding authority, included: The shielded arc, it's value and use in design; calculating stress distribution in welded joints; use of rubber weld models and polarized light in study of stress distribution; determining the most economical section in changing from cast to arc-welded construction; weld inspection; checking fusion and penetration. The course also included a practical metallurgical study of the welding of ferrous and non-ferrous metal. A discussion of the characteristics of the welding arc was illustrated by projecting the arc on a screen. The course was divided into morning and afternoon sessions at the Lincoln plant and evening sessions at John Huntington Institute.

To The Buyers of . . .

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The United Supply & Manufacturing Company attempts to render a satisfactory and unique service. To do so requires a constant vigilance, an intelligent and competent organization, complete and well diversified stocks. We believe our nine stores and offices, strategically located, offer such requisites.

We are fittingly prepared to serve you competently and well. Our stocks are constantly being augmented and are designed to meet the exacting requirements of the hardest operating conditions of the Mid-Continent fields. Our organization renders a personal service. If United service is not already known to you, may we not anticipate the pleasure of acquainting you?

COMPETENT, COURTEOUS, EFFICIENT SERVICE

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H. B. GUTELIUS — C. J. HALLORAN — F. P. THIEMAN

Natural-Gas Reserves in Three Horizons of Oklahoma City Field Estimated

THE Bureau of Mines, Department of the Interior, estimates on the basis of calculations made by the "pressure-volume" method that the Layton, Oolitic, and Oswego-Prue gas-producing horizons in the Oklahoma City oil field contained a combined initial gas reserve of approximately 267.6 billion cu. ft., that 214.6 billion cu. ft. has been withdrawn from these formations up to January 1, 1936, leaving a gas reserve of 53 billion cu. ft., based upon an abandonment pressure of 100 lb. per sq. in. gauge at the well head.

These figures are the result of a study by R. E. Heithecker, petroleum engineer of the Bureau, who suggests that as the reservoir pressure declines nearer the assumed abandonment pressure the rate of withdrawals no doubt will become less and less, and the producing life of each zone will be extended for a much longer period than indicated by abandonment dates computed on the basis that the rates of withdrawal from these zones will continue at the same levels as have been maintained over the last several years.

The report dealing with this subject, which recently has been issued by the Bureau of Mines, is of special interest to petroleum and natural gas engineers as it presents data permitting a direct comparison of results of estimating gas reserves in the same zones by two generally recognized methods, namely the "porosity-area" method and the "pressure-volume" method.

In June, 1933, the Bureau of Mines, in cooperation with the State of Oklahoma and the Oklahoma City Chamber of Commerce, published Report of Investigations 3217 on the gas reserves in the Oklahoma City oil field based upon data as of October, 1932, at which time there were 43 classified gas wells in the field. The estimates were obtained by the "porosity-area" method.

The porosity-area method, as used in this earlier report by H. B. Hill and E. L. Rawlins, petroleum engineers of the Bureau, is used when a gas field is comparatively new but after enough drilling has been done to determine the average thickness, porosity, and areal extent of the producing horizon. The "pressure-volume" method of estimating gas reserves, the method used in the later Bureau report, may be used after a sufficient volume of gas has been withdrawn from the reservoir to cause an appreciable decline in reservoir pressure.

Since October, 1932, many wells have been plugged back from pre-Pennsylvanian oil horizons and completed as gas wells in the Pennsylvanian horizons (which include the Layton, Oolitic, and Oswego-Prue), and several wells have been reclassified from one producing zone to another in accordance with provision of the Oklahoma Corporation Commission. In the Oklahoma City field 131 gas wells and 29 oil wells were producing from the Pennsylvania horizons on January 1, 1936.

The estimates of the total original reserves from the Layton zone made by the porosity-area method as of October, 1932, and those made on the pressure-volume basis, three years and nine months later, are virtually the same—47,270,000,000 cu. ft. compared with 47,174,466,000 cu. feet. Apparently, the factors considered in the earlier report in establishing the premise that 50 percent of the gas in place would be recovered from the Layton zone should be revised in the light of increased knowledge regarding the Oklahoma City field, as it now seems that approximately 100 percent of the gas will be recoverable.

The estimate by the porosity-area method of the gas reserves in the Oolitic zone was 41,230,000,000 cu. ft. compared with 35,390,083,000 cu. ft. by the pressure-volume method, a difference of 5,839,917,000 cu. feet. Based upon these figures, it appears that the recovery from that zone will be more nearly 85 than 50 percent of the former estimate of total reserves.

There is a still larger difference in the estimates of total reserves from the Oswego-Prue zone by the two methods. The porosity-area method gave an estimated original reserve of 143,720,000,000 cu. ft., as compared with 185,035,181,000 cu. ft. by the pressure-volume method. The principal reason for this difference may be that the areal extent of the Oswego-Prue gas horizon later was found to be larger than that originally estimated. The areal extent of the Oswego-Prue horizon originally was considered to be that within the 4850-ft. contour line on the Oswego limestone, whereas later developments have shown the areal extent of this horizon to be considerably larger.

The study of the two methods of estimating gas reserves from the gas zones in the Oklahoma City field shows that both methods give comparable results only when sufficiently accurate data are available. The results of the Layton and Oolitic estimates by the porosity-area method as compared with the estimate by the pressure-volume method later in the life of the field, are in line with good engineering estimates. The recovery factor, however, as applied to the earlier estimate, now is known to have been too low. Based upon the more recent study of the Oswego-Prue zone, it is known, also that where the areal extent of the producing formation is subject to inexact determination, considerable error is possible when original reserves are estimated by the porosity-area method.

With general reference to estimating natural-gas reserves, the Bureau of Mines report states that the porosity-area method is the only method available to calculate or estimate the gas reserves during the early life of a gas field. The more information the engineer has at hand regarding the areal extent of the field, the effective porosity, thickness and temperature of the producing formation, location of the gas-oil or gas-water contacts, and deviation of the gas from Boyle's law, the more accurate the estimate can be made. Later in the life of the field after a sufficient quantity of gas has been withdrawn from the reservoir to cause an appreciable drop in formation pressure, the estimates of reserves may be calculated by the "pressure-volume" method. The required data are total amount of withdrawals from the reservoir in intervals of one, three, or six months, depending upon the age of the field; shut-in well-head pressures at intervals during the producing life of the wells and information regarding the temperature of the reservoir; water encroachment; and the deviation of the gas from Boyle's law.

Obviously, it is impossible to calculate exactly the quantity of gas in a horizon. When any one of the many factors considered in setting up the estimate is in error, the final figure of gas reserves will be inaccurate in proportion to the influence this factor has upon the final answer. The older the field, however, (provided reasonably accurate data are available as to all the factors considered in making the estimate) the more accurate the final estimate will be, regardless of the method used.

Copies of Bureau of Mines R. I. 3338, Estimate of Natural-Gas Reserves from the Layton, Oolitic, and Oswego-Prue Horizons in the Oklahoma City Oil Field, by R. E. Heithecker, may be obtained without charge upon request to the Information Division, Bureau of Mines, Washington, D. C.

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"Digs Anywhere —Anytime"

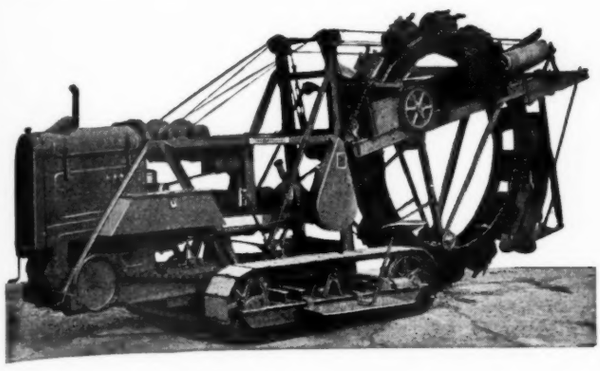

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Illustration below shows "Model 110" on trailer on which it loads or unloads in 10 to 15 minutes

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OF
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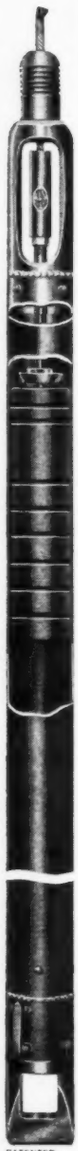
MILLER SAND PUMPS ARE USED IN CLEANING OUT WELLS THAN ALL OTHER SAND PUMPS MADE

The Reason

IS BUILT INTO THE MILLER

● THE RESULT

. . is oil in your tanks in place of sand in your well. Get **FULL** *production from your wells,* **CLEAN OUT** *with a* **MILLER.**



The MILLER is made in diameters of 2½, 3, 3½, 4, 4¼, 5, 5½, 7 and 9 inches and lengths of 20, 25 and 30 feet. 5/32-inch wall thickness in REGULAR Type, ¼-inch wall tubes HEAVY Type Sand Pumps.

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To Meet Every Condition

● **BAILER BOTTOM**

With the Bailer Bottom installed the MILLER is quickly changed to a Bailer giving you a combination of either Bailer or a Sand Pump in one tool.

● **SAND BOTTOM**

Used when tools are run and when well is shot to quickly remove loose material.

● **STAR BOTTOM**

Used for cutting the sand loose.

● **CHISEL BOTTOM**

(In Pump)

With this bottom tightly packed sand can be easily broken in small pieces so it can be picked up in the pump.

Write for Descriptive Folder and Price List

See Page 1186 COMPOSITE CATALOG

PATENTED
NO. 1370340
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NO. 1787390
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MILLER Sand Pump Co.

General Offices and Shop, Box 4516
OKLAHOMA CITY, OKLA., U. S. A.

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SAPULPA, OKLA. and KILGORE, TEX.

FOR SALE BY SUPPLY STORES EVERYWHERE

Rockefeller Gift Paved Way for Research in Petroleum

A gift of the late John D. Rockefeller that will have a continuing influence upon human welfare long after his passing was his establishment in 1925 of a $250,000 fund to finance fundamental research in petroleum geology, physics, and chemistry. The immediate effect was not only the creation of petroleum research fellowships at American colleges and universities, but the awakening of an interest in the possibility that petroleum is a source material as prolific of useful products as coal tar.

Prior to Mr. Rockefeller's gift and the inauguration of a program of fundamental research under the auspices of the American Petroleum Institute, emphasis in research among organic chemists in colleges and universities had been placed largely upon coal tar and its derivatives. Since that time, however, there has been considerable and growing research in the field of petroleum as organic source material, not only in colleges, universities, government, and other research agencies, but in the petroleum industry itself. Results already have indicated the possibility of obtaining from petroleum sources, under proper economic conditions, a growing number and variety of useful products.

Mr. Rockefeller's $250,000 gift was made payable in annual installments of $50,000 for five years from the date of its establishment, November 15, 1925. On January 12, 1926, the Universal Oil Products Company, of Chicago, established an equal sum in furtherance of the same program, thus making $100,000 per year available for five years of petroleum research. The Institute's program still is functioning although on a somewhat limited scale.

With the aid of the Rockefeller and Universal funds, the Institute inaugurated a program of 43 fundamental research projects and established research fellowships permitting utilization of qualified personnel and laboratory equipment at universities, technical institutions, and government bureaus. The co-operation of the National Research Council was obtained, and research work begun at the U. S. Bureau of Standards, the U. S. Geological Survey, as well as at California Institute of Technology, Massachusetts Institute of Techonolgy, Mississippi College, Pennsylvania State College, and at Stanford, Princeton, Johns Hopkins, Harvard, Northwestern, California, Illinois, Michigan, Texas, Oklahoma, Brussels, Minnesota, and other universities.

Research studies in petroleum geology and physics were concerned with determining the source, properties, and characteristics of petroleum and the compilation of data helpful in discovering adequate sources of supply and developing efficient methods of recovery. Research in petroleum chemistry, and to a degree in petroleum physics also, were directed toward determining the composition of petroleum and to collecting data regarding the behavior of the constituents and fractions of petroleum, and use of the liquid mineral as a source material.

R. W. Law Promoted

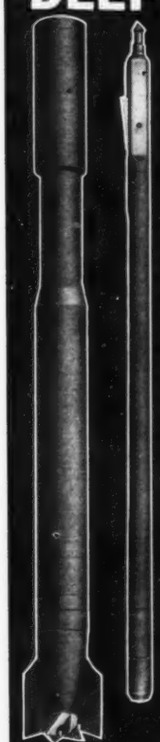
M. J. Czarniecki, vice-president in charge of sales, A. M. Byers Company, Pittsburgh, Pennsylvania, announces the appointment of Robert W. Law as division manager of their Boston office, 518 Consolidated Building. Law has been with A. M. Byers Company since 1925 as sales representative in the New York Division. He succeeds J. J. Riley.

DEEP CORING

with Quick Accurate Results is assured with the

HUNT

Retractable Barrel



Nobody knows, better than the Contractor, how coring failures take the profit out of a deep hole . . . and nobody knows, better than the Contractor, the many advantages of the HUNT WIRE LINE BARREL, especially where great depths are drilled. Hard and Soft formation heads interchangeable.

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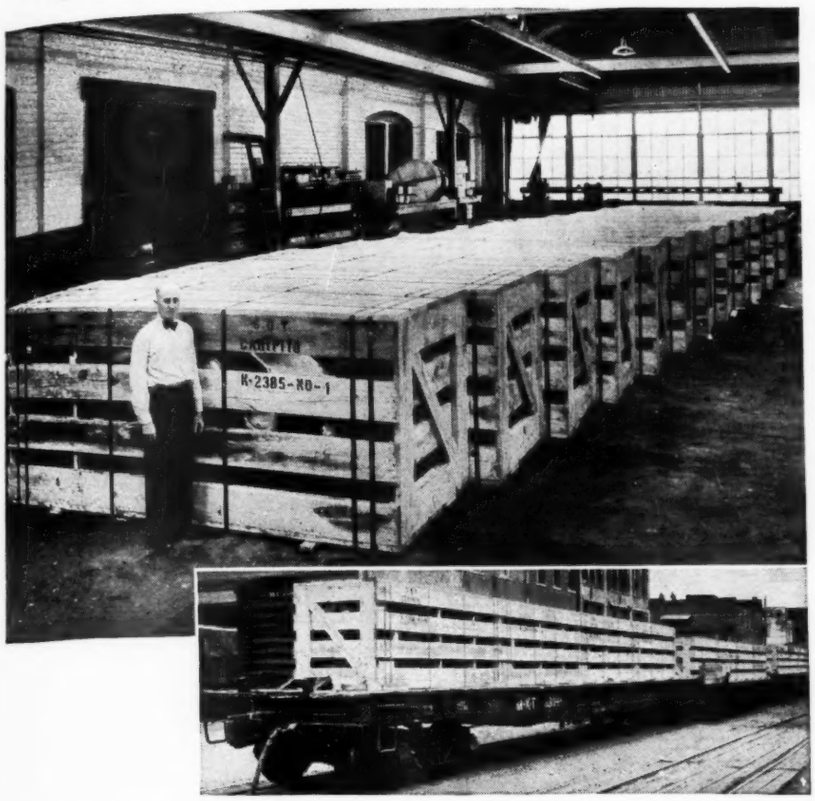
HOUSTON TEX.
Patents AUTHORIZED APPLEMAN BIT SERVICE CO.
HUNT WIRE LINE CORE BARRELS

BIT SERVICE SHOPS:
Houston, Joinerville, Talco, Corpus Christi, Bay City, Alvin, Texas . . . . . Rodessa, Jennings, Houma, Louisiana.

Big Export Shipment of Gaso Pumps to Venezuela



One of the largest single export shipments of oil-field equipment that recently has been made from the Mid-Continent is here pictured. Each of the big crates contains a Gaso Duplex Piston Power Pump for oil pipe line service, and they are being shipped to one of the leading oil companies operating in the oil fields of Venezuela, South America. Weight of the 12 big crates totals 110,000 lb., or 55 tons.

The pumps are known as Gaso Fig. 1740. They are designed for gas engine drive and are capable of pumping 6000 bbl. each, daily, at a pressure of 650 pounds. The pumps, from raw materials to finished product, were manufactured entirely in the Gaso Pump and Burner Manufacturing Company's Tulsa plant. The shipping boxes also were fabricated in the Gaso shipping department, which has had many years of experience in packing for export trade, as Gaso oil industry pumps are in use in every country that produces petroleum and have enjoyed a large export trade for many years.

The Gaso company takes an interesting precaution in connection with all products shipped abroad. After the pump is completely assembled and tested, it is taken down and every part is treated with a special corrosion preventive, to guard against corrosion from possible exposure to salt water or salt sea air. The pump is then reassembled and packed for shipment.

Oil Sands at Fort McMurray, Alberta, To Be Worked

According to officials of the Abasand Oils, Ltd., Edmonton, Alberta, Canada, the experiments in refining of oil sands at Fort McMurray, Alberta, conducted during 1936 and 1937, have been successful. It is reported that a separation plant with a daily capacity of from 250 to 400 tons has been erected, together with housing quarters for workmen. According to the present plans, a refinery will be constructed during the summer of 1937 and placed in operation early in the fall. A refinery capable of producing 300 bbl. of oil daily has been considered, from which it is expected to produce approximately 60 bbl. daily of high-test gasoline.

STRAIGHT TALK.... about CROOKED HOLES

Write for literature

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1608 Walnut Street, Philadelphia, Pa.
425 Petroleum Building, Tulsa, Okla.
3118 Blodgett Avenue, Houston, Texas
549 East Bixby Road (3800 Block—Atlantic Ave.) Long Beach, Calif.
Bank of Lafayette Bldg., Lafayette, La.
c/o Elks Club, 17th and I Streets, Bakersfield, Calif.

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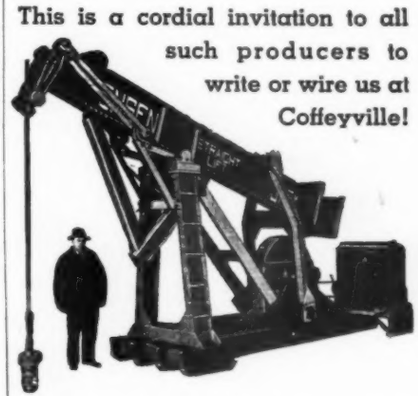
... is something the average New Yorker has never tasted. And he doesn't know what he's missing! Same way with the producer who has never used a JENSEN Straight-Lift JACK. He is missing out on the finest piece of equipment ever developed for lifting oil. But he doesn't know it.

This is a cordial invitation to all such producers to write or wire us at Coffeyville!

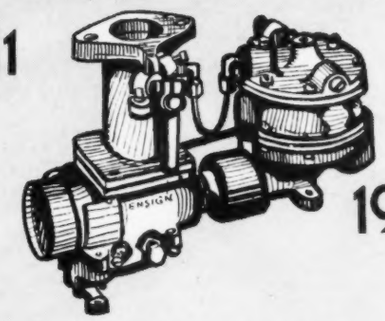


JENSEN BROTHERS MANUFACTURING CO.

. . . Coffeyville, Kansas

ENSIGN

1911



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A Pioneer . . . . . and a leader in the design, development and manufacture of fine precision carburetors and fuel regulating equipment for more than a quarter of a century.

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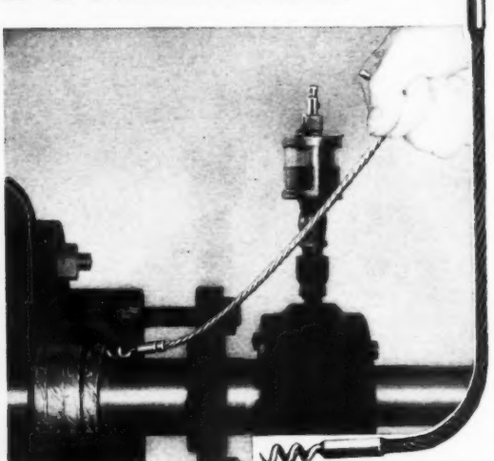

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This new and handy tool puts an end to time-wasting methods of removing packings. Built for severe service . . . patented tool steel flexible cable . . . corkscrew bits of tempered tool steel. Write for prices.

Sturdy ALL STEEL PACKING REMOVER

SIZES

Made in 6 lengths: 7½", 11", 15", 19", 22" and 30".

Made by the manufacturers of DURAMETALLIC Packings—the reliable packing for all mechanical and chemical requirements.

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Book Reviews

High-Speed Diesel Engines. (Second edition.) By P. M. Heldt. Published by P. M. Heldt, Nyack, New York. 438 pp. 250 illus. Price, $4.50, postpaid to any address in the United States or Canada.

The type of Diesels discussed in this volume are those applicable to the automotive, aeronautical, marine, railroad, and industrial fields. Theory, design, applications, operations, and maintenance, as well as Diesel fuels, are covered completely and interestingly. The book also contains a chapter on other types of oil engines.

* * *

Distillation. By Joseph Reilly. Published by Methuen and Company, Ltd., London, England. Exclusive sales agents in North and South America: The Chemical Publishing Company of New York, Inc., 148 Lafayette Street, New York, New York. 118 pp. 45 diagrams. Price, $1.25.

The author, professor of chemistry in the National University of Ireland and a technical member of the Irish Free State Industrial Advisory Board, apparently has expended much time and effort in the preparation of this monograph, which contains a discussion of the theoretical and practical aspects in the various fields of distillation. The contents of the volume concern such subjects as fractionation, production and measurement of low pressure, vacuum fractionation, azeotropic mixtures, distillation in a current of steam, destructive distillation, and sublimation.

* * *

Tanker Technique, 1700-1936. By B. Orchard Lisle. Published by World Tankship Publications, 616, Cecil Chambers, Strand, London, W. C. 2, England. Price, two shillings.

To those interested in tankships this volume should prove a valuable possession. Between its covers are found a history of the growth and improvements in tanker design and construction technique from the earliest vessels. The author has accomplished his purpose by selecting ships that in his opinion best typify the tanker of the various periods covered, as well as mentioning exceptionally outstanding vessels of regular design. That portion of the volume covering late years, however, is restricted to ships of unusual design and others not covered by the "orthodox" tankship handbook, since several volumes have been published in recent years that adequately describe average types of modern vessels.

* * *

Petroleum, The Story of an American Industry. Prepared and published by the American Petroleum Institute, 50 West 50th Street, New York, N. Y., Price, 15 cents.

This is a second, and larger, edition of the book "Oil," published by the American Petroleum Institute in 1930. The volume has been prepared to give a better understanding of the operations of the petroleum industry, and to reveal at least some of the accomplishments and a few of the services rendered by the industry.

* * *

Petroleum Dictionary (Second Edition). By Hollis P. Porter. Published by the Gulf Publishing Company, 3301 Buffalo Drive, Houston, Texas. 253 pp. Price, $3.00.

Since even the most up-to-date general dictionaries do not contain all the words that have been introduced into the petroleum industry, the author has compiled this volume with a view to filling a definite need. The dictionary is offered as a ready reference to all employed or interested in the petroleum industry. The volume includes not only the practical terms, but also the technical words and terms used in the geological, chemical, mechanical, electrical, and civil engineering branches of the industry.

New Bulletin Describes Hydrauger Boring Machine

Hydrauger Corporation's newest bulletin explains in detail the Model 2A-2X Hydrauger machine. The powerful, compressed-air-driven unit has been developed for faster boring of horizontal underground holes. According to the company, bores now can be made in all diameters from 2½ in. to 14½ in. for distances of 175 feet. It is claimed that in several instances the new 2A-2X Hydrauger has saved its entire cost on a single pipe-laying job. These operations have included boring 60 ft. through solid granite, and stringing a 12-in. main under an eight-lane super highway. The clean straight Hydrauger bore simplifies pipe-line extension particularly for coated or wrapped pipe. Many interesting facts are contained in the new bulletin obtainable from the company's San Francisco office, 116 New Montgomery Street.

Many Attended Stripper Well Association Meeting in Tulsa

Representatives of 18 local, state, and area stripper well associations in nine oil-producing states gathered for the Fourth Annual Meeting of the National Stripper Well Association in Tulsa, Oklahoma, on June 17, at the Mayo Hotel.

This meeting considered national problems of the industry particularly those affecting the stripper well operators, such as proposed legislation providing for maximum hours of labor and minimum wages, the importation of crude oil and refined products, the Connally "hot oil" law, the Interstate Compact, pollution bills, and federal taxation problems.

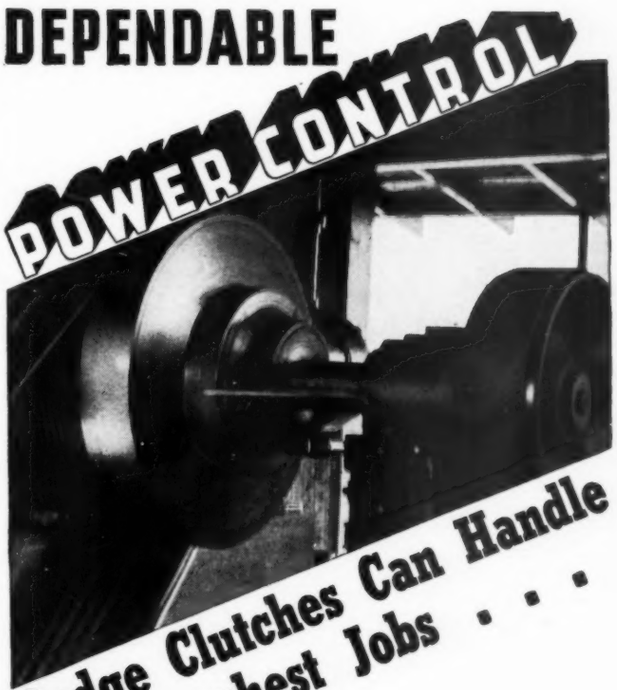
The following are the officers of the National Stripper Well Association: William Bell, Robinson, Illinois, president; H. B. Fell, Ardmore, Oklahoma, executive vice-president; P. B. Flynn, Wichita Falls, Texas, vice-president; and T. B. Steele, Robinson, Illinois, secretary-treasurer.

Members of the Executive Committee representing the member associations are as follows: Central Pennsylvania Oil Producers Association, Wm. J. Brundred and David B. McCalmont; Creek County Stripper Well Association, Eli Wilkonson and R. R. Kirchner; Fourth District Oklahoma Stripper Well Association, John H. Rebold and B. H. Young; Illinois-Indiana Petroleum Association, A. U. McCandless and Don F. Kerr; Kansas Stripper Oil Well Association, Clyde I. Layton and Carl Weiner; Lima Crude Oil Improvement Association, Carl H. Schwyn; Mid-Continent Royalty Owners Association, Robert H. Wood and Earl Sneed; Middle District Oil Producers Association, William O'Neil and Allison D. Wade; New Mexico Oil and Gas Association, Van S. Welch; New York State Oil Producers Association, D. J. Sweeney and George E. Holbrook; Northeastern Oklahoma Stripper Well Association, Howard J. Whitehill and C. C. Harmon; North Texas Oil and Gas Association, L. H. Cullum and C. P. McGaha; Northwestern Oklahoma Oil and Gas Producers Association, Harper Poling and T. T. Eason; Oil and Gas Association of Michigan, E. F. Clagett and James C. Graves; Oklahoma Stripper Well Association, H. B. Fell and W. W. Warner; Southern Oklahoma Oil and Gas Association, Will H. Smith and L. W. Winkler; West Central Texas Oil and Gas Association, Graham P. Crutchfield and W. J. Rhodes; Western Pennsylvania Oil Producers' Association, Carl R. Daugherty and H. H. Phillips.

New Catalog On Goulds Pumps

Goulds Pumps, Inc., Seneca Falls, New York, announces the publication of a new catalog covering its lines of centrifugal, reciprocating, and rotary pumps for industrial service. Each pump is presented completely with description, illustrations, specifications, ratings, and when desirable, dimensions.

DEPENDABLE POWER CONTROL



Dodge Clutches Can Handle the Toughest Jobs . . .

Dodge Diamond "D" Friction Clutches are efficiently, dependably, and economically adapted to power transmission as well as for application to various types of machinery used in the oil fields. They are ruggedly constructed and capable of handling 100% overload, insuring safety and protection and positive power control under any conditions of service.

See the Dodge 20-page section in the Oil Field Composite Catalog

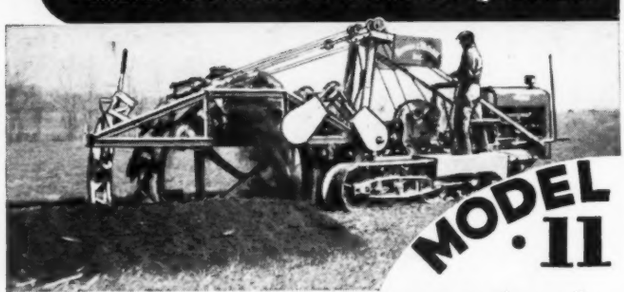
Specify Dodge Diamond "D" Clutches for steady, uninterrupted service. Send for copy of Catalog No. A-200.

DODGE MANUFACTURING CORPORATION
MISHAWAKA, INDIANA, U. S. A.

THE Right DRIVE FOR EVERY JOB

DODGE
MISHAWAKA
THERE IS ADDED VALUE IN THE NAME DODGE

A Buckeye DITCHER
for TRENCH 10" to 22" WIDE
• OVERALL WIDTH OF MACHINE ONLY 52"
• EASILY HANDLED IN CRAMPED QUARTERS



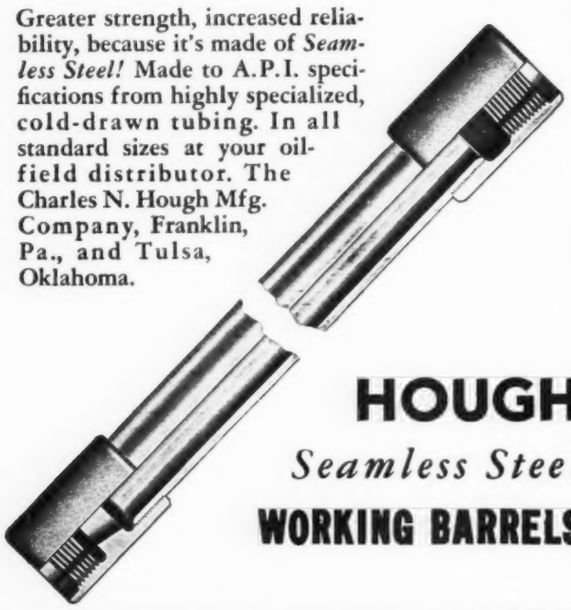
Big ditcher efficiency and economy comes to the small ditching field in the Buckeye Model 11. Built for steady, time saving operation, with speed for easy going and rugged strength for the toughest jobs – features of Buckeye engineering that always save you money on any job. Before you buy a ditcher, be sure you have the facts about Model 11.

This specially designed Buckeye trailer is for quick and easy transportation of the Model 11. The ditcher climbs onto the trailer under its own power, fully assembled.

THE BUCKEYE TRACTION DITCHER CO., FINDLAY, OHIO

A Working Barrel that
STANDS UP!

Greater strength, increased reliability, because it's made of *Seamless Steel!* Made to A.P.I. specifications from highly specialized, cold-drawn tubing. In all standard sizes at your oil-field distributor. The Charles N. Hough Mfg. Company, Franklin, Pa., and Tulsa, Oklahoma.



HOUGH
Seamless Steel
WORKING BARRELS

Clark Bros. Company Merges With Dresser

Official announcement has been made of the merger of Clark Bros. Co., Olean, New York, with S. R. Dresser Manufacturing Company, Bradford, Pennsylvania, thus verifying rumors current for some time that such a consolidation was pending.

Clark Bros. Co. are prominent builders of 2-cycle gas engines and compressors, having pioneered many of the improvements that have been made in gas-engine design in the 57 years they have been in business.

Equally as old and well-known is the S. R. Dresser Manufacturing Company, maker of flexible pipe joints used on many of the country's largest and longest gas-transmission lines. They also manufacture a complete line of pipe-line repair devices. A Canadian subsidiary, Dresser Manufacturing Company, Ltd., of Toronto, was established in 1931.

Both Dresser and Clark have served the gas and oil industries for more than half a century. In recent years, Dresser has entered the gas-engine field with a new radial-type gas engine and compressor of its own, of 2-cycle design. It is believed that the engine operations of both companies may be consolidated at Olean in the near future.

In June, 1933, the Dresser company acquired The Bryant Heater Company, of Cleveland, manufacturer of gas boilers, furnaces, conversion burners, unit heaters, and air-conditioning equipment. According to announcement then, Dresser felt that by this move it could contribute materially to the building of greater gas loads.

In the acquisition of Clark Bros. Co., observers also see a continuation of this program of constantly widening usefulness to the gas industry. Through this new association, with its combined resources for research activities and with its interchange of engineering knowledge and experience between the three companies, it is felt that new and significant improvements in products for the utilization of gas may be made possible.

The officers of Clark Bros. Co. are C. P. Clark, president; J. B. O'Connor, vice-president; and of the S. R. Dresser Manufacturing Co., Fred A. Miller, chairman of the board; H. N. Mallon, president; and M. N. Davis, executive vice-president.

John Mulcahy Assumes New Duties with Cavins Company

JOHN "SHORTY" MULCAHY

Paul Cavins, general manager of the Cavins Company, announces the appointment of John "Shorty" Mulcahy as supervisor of rental service agencies in the Mid-Continent fields. Before assuming his new duties, John was San Joaquin Valley (California) agent for the Cavins Company. For the time being he is making his headquarters in Oklahome City where an agency is being re-established for the handling of business in that area.

University of Kansas Establishes a Petroleum Engineering Department

The University of Kansas is expanding its work for the petroleum and gas industries by adding to its staff, establishing a new curriculum, and increasing the laboratory equipment. The first step to be announced in this program is the appointment of Dr. Eugene A. Stephenson to the position of professor of petroleum engineering.

Eugene A. Stephenson

Professor Stephenson took his Bachelor of Science degree at Adrian College, Michigan, and his doctor's degree of geology at the University of Chicago in 1915. During the period of 1912 to 1916, he was instructor in economic geology at the University of Chicago. In 1917 he was made chief geologist for the South Penn Oil Company of Pittsburgh, a position he held until 1925. During this time he was in charge of the geologic petroleum engineering work of the South Penn Oil Company in Pennsylvania, West Virginia, Kentucky, Texas, and Mexico. In 1925 he became associated with Ralph E. Davis, Inc., of Pittsburgh and New York, an affiliation that continued for five years. During this time he had active and varied experience with engineering problems in most of the important oil and gas fields of the United States, Mexico, and Canada. In 1930 he resigned from Mr. Davis' organization to become professor of petroleum engineering at the Missouri School of Mines and Metallurgy at Rolla, a position he has held for seven years.

Professor Stephenson has taken an active part in the affairs of the American Institute of Mining and Metallurgical Engineers and for the last five years has been secretary-treasurer of its Petroleum Division. He also has engaged in an extensive consulting practice, especially in Louisiana, Texas, and Oklahoma. He is a member of the American Association for the Advancement of Science, the American Association of Petroleum Geologists, Sigma Xi, Missouri Academy of Science, and the American Gas Association.

The increase of staff is a part of an extensive program of development that seems to be demanded by the growing importance of oil and gas in the state.

The new curriculum will recognize the necessity of thorough training in the fundamental sciences on which all progress in petroleum engineering must be based. Also experimental work will be carried on that will deal with problems of importance to both the industry and the state, such as salt water disposal, and stimulation of production.

H. C. Mougey Named to Executive Committee A.S.T.M.

H. C. Mougey, chief chemist and assistant technical director, Research Laboratories Division, General Motors Corporation, has been named to the executive committee of the American Society for Testing Materials for a two year term.

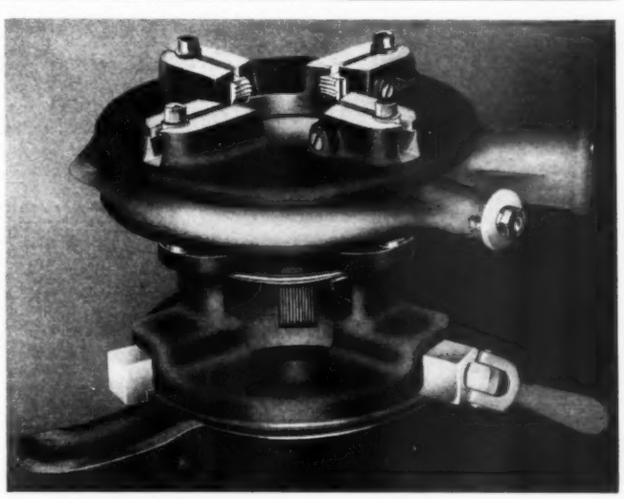
After he received his degree of B.S. in chemical engineering from Ohio State University in 1911, he was affiliated with the Lowe Brothers Paint Company, Dayton, Ohio, until June, 1917. Then until 1920 he was with the Dayton Metal Products Company, Research Division, and from 1920 to 1925 was with the General Motors Research Corporation, Dayton. Since 1925 he has been in the Research Laboratories Division, at Detroit. In 1935 he received the professional engineering degree of chemical engineer from Ohio State University. He has been particularly active in the Society in the work of Committee D-2 on Petroleum Products and Lubricants and for several years has been chairman of Technical Committee B on Motor Oils.

With both Flow Control and Pressure-Control Regulators *this Valve is* APPROVED

The V-Port gradual-opening valve here shown is thoroughly dependable with flow controllers and instrument-type auxiliary-controlled pressure regulators and with many other forms of refinery equipment. Has many applications also in other industries. Made for either direct action (closed by diaphragm pressure) or indirect action (opened by diaphragm pressure). Sizes ½-inch up, all with ample diaphragm area to give positive unfailing response.

CF V-PORT MOTOR VALVE

The
CHAPLIN-FULTON MFG. COMPANY
28-40 Penn Avenue Pittsburgh, Pa.



A "DeLuxe" 4-post Threader

The Beaver "9-R" threads 1, 1¼, 1½ and 2-inch—using 4 sets of dies. It is made of unbreakable Air Furnace Malleable Iron. The straight-line pull (ratchet on the die head) insures easier pulling; smoother operation; less repair expense. Die segments are standard and interchangeable. Universal chuck centering device—quick and accurate—permits cutting uniform drip threads or close nipples. Resale price, $15.00 ... through your jobber.

Also No. 9 non-ratchet and No. 9-RX two-handle ratchet

Write for complete catalog—35 new Beaver Tools

BEAVER PIPE TOOLS

737 PETROL AVENUE WARREN, OHIO

Ball-Bearing Grease-Packed

Positively Locked until Released

B-M-W NEILSON

Safety Sucker Rod Hooks

Here is a hook that assures 100% safety because of its very simple and rugged latch arrangement combined with free swiveling and a grease packed bail. Two sizes for rods. One size for tubing. Circular on request.

Obtainable at Supply Stores

Principal B-M-W Products are obtainable at supply stores, including: • ADMORE Insert Pump Anchors; • NEILSON Tools (Safety Sucker Rod Hooks, Tubing Hooks, Rod Elevators, Sucker Rod Sockets, etc.); • BALLS and SEATS (made for every pumping service); • ADMORE Liner Barrels; • TEX TYPE Plunger Fittings and Valves; and • COLLINS Belt Clamps.

BRADFORD MOTOR WORKS INC.

OIL WELL SUPPLIES

BRADFORD, PA. — TULSA, OKLA.

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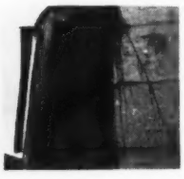

Photo No. 1 shows wide coverage of storage tank by patented Oakite Flow-On method. Possesses rapid paint removing qualities. No objectionable fumes. Rinses freely .

Photo No. 2 shows hose rinsing which carries away loosened paint, leaving base metal surface in good condition for repainting.

Photo No. 3 shows portion of stripped section indicating complete paint removal.

Complete details of this rapid, EXTREMELY ECONOMICAL method of reconditioning storage tanks will be gladly sent to any one interested in doing this work. Successfully used right now by leading oil companies. Write for complete data. No obligation.

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Interests of the Compagnie Francaise Des Petroles in Iraq Oil Developments

On the occasion of its increase of capital from 475,000,000 to 600,000,000 francs, the Compagnie Francaise des Petroles has issued some information relative to its activities during 1936.

The bases of the company's operations are in its participation in the Iraq Petroleum Company and in the construction of two refineries in France by a subsidiary, la Compagnie Francaise de Raffinage.

The company has the right to 23.75 percent of the production of the Iraq Petroleum Company, the exclusive concessionnaire in the Northeast of Iraq for 75 years. In 1934, its share was 1,168,500 bbl., 6,046,000 bbl. in 1935, and 6,579,500 bbl. in 1936. It is believed that the deposits of Kirkuk can supply the pipe lines from Iraq to the Mediterranean for many years.

The Iraq Petroleum Company increased its capital to 14,500,000 pounds sterling following the absorption of its subsidiary, the Mediterranean Pipelines, Limited.

The groups constituting the Iraq Petroleum Company, after thorough exploration, have created a holding company, the Petroleum Concession, Ltd., combining subsidiaries to assure exclusive rights for research and concessions in Arabia, the Red Sea Coast, the Persian Gulf, and Syria. These companies are: The Petroleum Concession (Syria Lebanon, Ltd.); The Petroleum Development, Ltd. (Qatar); The Petroleum Development, Ltd. (Trucial Coast); The Petroleum Development, Ltd. (Western Arabia).

The same interests have created the Mosul Holdings that controls the Mosul Oil Fields, of which the subsidiary, British Oil Development, has the concession of the Iraq zone north of the 33rd parallel and west of the Tigre. Nearly 50 drillings on the concession have given evidence of the productivity and exploitation is in preparation. The Compagnie Francaise des Petroles is interested in 23.75 percent of the production of the new participations, as well as in that of the Iraq Petroleum Company.

The Compagnie Francaise des Petroles owns 55 percent of the capital of the Compagnie Francaise de Raffinage, which was organized with the participation of the Government and French oil distributing units. The Compagnie Francaise de Raffinage operates two refineries in France, the "Normandie" and the "Provence," with a total annual throughput of 17,500,000 bbl. of crude.

Participating with the French Office National des Combustibles Liquides, the Compagnie Francaise des Petroles has been active in prospecting for oil in Morocco and Tunisia as well as in Gabon, Equatorial Africa and Madagascar.

Corrected Formula

In the article "Thick Belts on Oil Machinery," appearing on page 70 of the June issue of *The Petroleum Engineer*, the formula given is in error because of the omission of plus signs. The corrected formula should read as follows:

$$n = N \frac{(D + t)}{(d + t)}$$

Where

n = r.p.m. of driven pulley
N = r.p.m. of driving pulley
D = dia. of driving pulley, in.
d = dia. of driven pulley, in.
t = thickness of belt, in.

Ira E. Dugan Opens Office As Consultant

Ira E. Dugan, who recently resigned his post with the Oklahoma Corporation Commission, after being deputy proration umpire in charge of the Fitts pool since its beginning, has opened a general consulting office in the Cummings Building, Ada, Oklahoma. He will handle geological, valuation, proration, and petroleum engineering work.

J. F. Lincoln In England for Series of Talks

J. F. Lincoln, in whose honor was created The James F. Lincoln Arc Welding Foundation, sponsor of the $200,000 Arc Welding Award Program, is in England giving a series of talks at the invitation of various engineering societies and institutes. Groups before whom Lincoln is scheduled to speak include the South Wales and Monmouthshire Institute of Engineers, the Institute of Engineers and Shipbuilders of Scotland, the Institute of Mechanical Engineers in London, and others.

Lincoln is director of Lincoln Electric Company, Ltd., London, England, affiliate of The Lincoln Electric Company, Cleveland, Ohio, of which he is president.

McColl-Frontenac Oil Company Seeks Trinidad Crude

At the annual meeting of shareholders of the McColl-Frontenac Oil Company, Ltd., Montreal, Canada, President John Irwin referred to the firm's oil properties in Trinidad, acquired in 1935, as follows:

"***we now have drilling rights on more than 35,000 acres of potential oil-producing properties, *** acquired from several owners, including the Government in Trinidad. Seismographic and geographical surveys now are being made, the results to date being most encouraging.

"Our operations in Trinidad are carried on through a subsidiary, all the shares of which we hold. We have invested approximately $900,500 in this subsidiary and we have advanced to that company approximately $410,000, or a total of $1,310,500.

"The very first well we drilled struck oil, although the gravity is heavy. Since that time we have continued drilling, with the result that our production has steadily increased until now we are producing at the rate of 40,000 bbl. per month.

"We have drilled 18 wells at depths varying from 1350 to 5755 ft. and two are now in the process of drilling. All but two of the 18 well have proved to be oil producers.

"So far we have not brought any of this oil to the Montreal refinery because of its heavy gravity, but have been selling it on the open market. Oil of a lighter gravity and such that it would be brought to Montreal for refining is being currently produced by other producing companies in Trinidad; in fact, we have purchased some oil from Trinidad in the past for refining purposes."

Search for Oil In Britain

According to the "Financial Times," 19 additional prospecting licenses to drill for oil in England have been issued by the Board of Trade. Of these, ten have been granted to the D'Arcy Exploration Company covering an area of approximately 1649 square miles in Kent, Sussex, Surrey, Yorkshire, Nottinghamshire, Derbyshire, Staffordshire, Shropshire, and Cheshire. Nine licenses have been granted to the Gulf Exploration Company (Great Britain), covering areas aggregating about 1277 square miles in Kent, Sussex, Dorset, Wiltshire, Somerset, and Yorkshire.

The D'Arcy Exploration Company also has acquired licenses to operate in Scotland.

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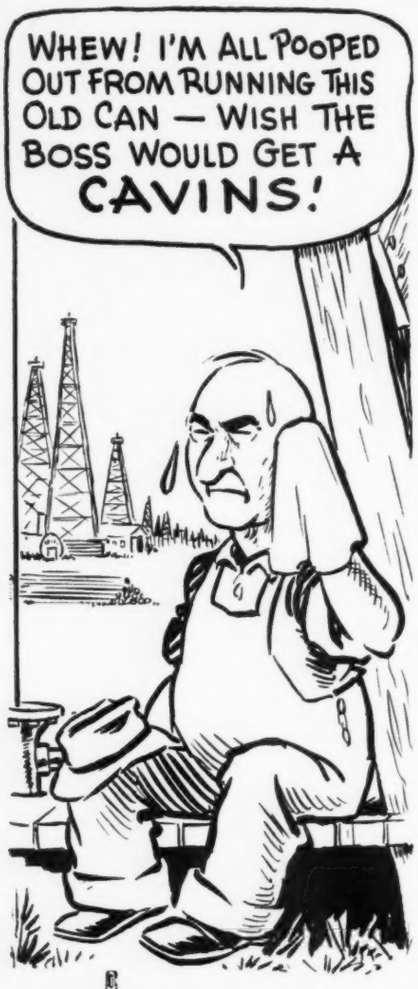

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